

A retrospective study of eyeball rupture in patients with or without orbital fracture

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Abstract

To summarize the clinical features of eyeball rupture with or without orbital fracture and explore the differences between them.

In all, 197 patients were observed, and the following data were recorded: sex, age, time of injury, place of injury, cause of trauma, zone of eye injury, intraocular content prolapse, surgical methods and the therapeutic process, visual acuity after injury, and the final best corrected visual acuity. The results were analyzed for statistically significant differences.

There was no significant difference ($P > .05$) in the age, sex, or cause of injury. Patients with eyeball rupture with fracture had poorer vision than did those in the simple eyeball rupture group; eyeball rupture with fracture also had a higher probability of enucleation.

In this study, the clinical results show that prognosis of eyeball rupture with orbital fracture is worse than that of eyeball rupture without orbital fracture.

Abbreviations: CI = confidence interval, logMAR = logarithm of the minimum angle of resolution, OR = odds ratio, SD = standard deviation.

Keywords: enucleation, eyeball rupture, orbital fracture, prognosis, visual acuity

1. Introduction

Eyeball rupture is 1 of the most serious types of open globe injury, and the prognosis of eyeball rupture is very poor. The types and severity of ocular trauma are significantly correlated. The wound locations of open globe injury can be classified into 3 zones. Zone 1 refers to damage to only the cornea and limbus, zone 2 refers to an injury extending less than 5 mm from the limbus to the sclera, and zone 3 refers to lesions longer than 5 mm over the limbus. A common injury of zone 1 is corneal laceration; zone 2 injury mainly involved in the anterior segment, such as hyphema, lens opacity, and lens dislocation; and zone 3 injury can cause damage to the posterior segment, such as damage to the pars plana, choroid, retina, and optic nerve. In this study, eyeball ruptures combined with orbital fractures were more involved with zone 3. The prognosis of simple anterior segment trauma is better. The final visual acuity is often poor after an eyeball rupture that is caused by injury to the posterior segment of the eye, which is

particularly associated with endophthalmitis, intraocular foreign body, and retinal detachment. These are the main causes of monocular blindness after ocular trauma.^[1] At present, it is believed that the most closely related factors of final visual function are the initial visual acuity, the integrity of the eyeball, endophthalmitis, retinal detachment, and the relative afferent pupillary defect.^[2]

Orbital fracture is a type of severe ocular trauma that frequently occurs due to a significant blow directly to the eye, such as from a road accident, boxing, explosion, or falling^[3]; such tremendous power can make the eye quickly recede into the orbit. As a result, the intraorbital pressure drastically increases, causing weak areas in the orbital wall to fracture^[4]; fractures of the inferior orbital wall and the medial orbital wall are more common.^[5] The main clinical manifestations of orbital fracture are enophthalmos, strabismus, diplopia, and eyeball movement disorder.^[6]

In clinical practice, patients with simultaneous eye injury and orbital fractures may be encountered. When the eyeball rupture injury is complicated with orbital fracture, it is necessary to determine whether more serious visual function damage will follow. It is also important to determine the prognosis of visual function. There is limited research on these topics at present.^[1,7] Thus, in the current study, we analyzed patients' records with eyeball rupture with or without orbital fractures in our hospital, and we studied the effect of orbital fracture on the prognosis of eyeball rupture.

2. Methods

2.1. General information

In this retrospective study, we analyzed the records of 197 cases of eyeball rupture in the Chinese People's Liberation Army General Hospital from January 2003 to January 2016, including 98 cases with orbital fracture and 99 cases of eyeball rupture without orbital fracture. The local ethics committee agreed to this noninterventional retrospective study exemptions ethical approval and informed consent.

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2.2. Outcome measures

We recorded the general information of the patients, including sex, age, injury time, injury place, cause of trauma, side of the eye, type of ocular trauma, intraocular content prolapse, surgical methods and the therapeutic process, initial visual acuity, and final follow-up visual acuity.

2.3. Surgical methods

A main principle in the treatment of eyeball rupture is to perform the primary suture operation as soon as possible. For the eye, if the wound alignment was not ideal after wound closure, the wound was re-stitched within 1 week of the injury. All of the lines of rupture were carefully stitched, and the uvea and retinal tissue were carefully returned. According to the nature of the injury, the secondary vitreous surgery was described as per the following principles: emergency surgery, such as for copper foreign bodies or suppurative endophthalmitis, was conducted within 1 week of the injury; subemergency operation, such as for a nonmagnetic intraocular foreign body, vitreous hemorrhage, or retinal detachment, was conducted 1 to 2 weeks after the trauma; foreign bodies in the posterior segment, according to the size and property of the foreign body, endophthalmitis, and bleeding, required an early suture operation with a concurrent or secondary vitreous surgery strategy; and vitreous surgery included the following: resection of the lens opacity to address the accumulation of blood or inflammation of the vitreous and traction bracing cable, the scleral pressure method for the possible removal of the vitreous base, and when the retina was shortened, a retinal incision was performed to promote attachment. Laser photocoagulation was performed around the retinal breaks. For suppurative endophthalmitis, retinal detachment with bleeding, or tractional retinal detachment with inflammation, an intraocular injection of silicone oil was administered; for other retinal detachments, long-term inert gas filling was performed. A small number of cases had artificial lenses implanted in the secondary operation. In all, 168 patients underwent vitrectomy with silicone oil tamponade, among which 130 underwent subsequently silicone oil extraction. In patients with eyeball rupture combine orbital fracture, a priority treatment of eye rupture is immediately. Patients with orbital rupture will have a local cold compress of orbital within 48 hours after injury, and for patients with diplopia and eye movement restriction, orbital fracture reduction surgery was done within 10 to 14 days after injury.^[8,9] Dr Yi Yao, Dr Fengxiang Wang, and Dr Tiecheng Liu performed these surgeries. The patients were followed up from 11 to 24 months after operation. Nineteen cases (9.6%) were lost to follow-up. Follow-up time less than 11 months and lost follow-up cases were excluded from our study.

2.4. Statistical analysis

To facilitate statistical analysis, the decimal best corrected visual acuity was converted to the logarithm of the minimum angle of resolution (logMAR) units, which was used for the statistical analysis, but there were too much light perception records that could not be converted to logMAR, so we used light perception as a measure of visual acuity.

Data are expressed as the means \pm standard deviation (SD) for continuous variables, and significant differences between groups were determined using Student *t* test. Chi-square analysis was used to compare groups with categorical variables. Odds ratios (ORs) with 95% confidence interval (CI) were estimated using

logistic regression models. A *P* value of 0.05 or less was considered significant.

3. Results

The 197 patients were followed up for an average of 17 months (from 11 months to 2 years). The silicone oil was removed 3 to 6 months after operation. Eight patients underwent lensectomy with intraocular lens implantation. The final best corrected visual acuity was recorded after silicone oil removal; alternately, if the intraocular lens was implanted, the observed indexes were recorded at the time before silicone oil removal.

3.1. General conditions

The basic information of patients (eyeball rupture versus eyeball rupture with orbital fracture) is shown in Table 1. There were no significant differences in age, sex, or cause of injury ($P > .05$).

A total of 98 eyes with eyeball rupture and 99 eyes with eyeball rupture complicated with orbital fracture were assessed. The causes of injury included work, fighting, traffic accident injury, blast injury, sports injury, and shooting (Table 1).

Patients with fracture had a worse visual acuity at the last follow-up time, and the probability of enucleation of the eyeball was higher than that of simple rupture group. Analysis of the results concerning the zone of eye injury revealed that eyeball rupture complicated with orbital fracture group resulted more in zone II and III injuries, with a statistically significant difference between the groups ($P = .029$). After an inspection of light perception, it was clear that eyeball rupture combined with fracture group resulted in worse visual function; the initial light perception ratio was 62/29 ($P = .021$), and the terminal point light perception ratio was 85/46 ($P = .019$). Uveal tissue prolapse was observed in both groups, with 15 cases and 55 cases ($P = .001$). The evisceration ratio was 14/35 ($P = .001$) (Table 2).

We choose the final light perception as the dependent variable; after adjusting for confounding factors, binary logistic regression analyses were performed. The results showed that the fracture ($P = .021$), partition of ocular trauma ($P = .013$), and enucleation ($P = .001$) had a significant statistical impact on the final light perception (Table 3).

Table 1
General information.

	Rupture	Rupture + orbital fracture	<i>P</i>
Number of eyes	99	98	.98
Patients	99	98	.98
Age	33.0 (19.9)	35.3 (11.8)	.83
Sex, M/F			
Male	90	85	.71
Female	9	13	
Eye			
Right	40	50	.37
Left	59	48	
Cause of injury			
Job injury	29	17	.06
Fighting	17	13	.23
Traffic accident	17	15	.38
Explosive injury	20	22	.55
Sports injury	16	26	.59
Gun shot	0	5	.02

F = female, M = male.

Table 2
Clinical characteristics of 2 groups.

	Rupture	Rupture + orbital fracture	P
Zone of injury			.029
I	28	9	
II	18	21	
III	53	68	
RD	97	90	.932
VH	93	88	.919
IOFB	11	8	.759
Endophthalmitis	0	0	—
Hyphema	75	88	.862
Initial light Perception	62	29	.021
Final light perception	85	46	.019
Lens surgery	15	10	—
Uveal prolapse	15	55	.001
Evisceration	14	35	.001

IOFB=intraocular foreign body, RD=retinal detachment, VH=vitreous hemorrhage.

4. Discussion

The rupture of the eyeball can result from a blunt force acting on the eyeball, which increases the intraocular pressure. High internal pressure causes a break through from the inside out, resulting in damage to the fiber layer of the eye wall. These may be associated with uveal and retinal laceration and with different degrees of prolapse of the intraocular contents. Orbital fracture can result from a blunt force blow to the front of the orbit, resulting in a sudden increase in the pressure of the orbit. The force is transferred to the orbital wall, which causes a fracture to occur on the weak side of the orbital wall.

The major causes of orbital trauma were traffic accidents, high fall injuries, and blunt force trauma to the head and face. Minor wound only resulted in orbital tissue injury, whereas severe cases were associated with the involvement of the adjacent organs and brain, resulting in loss of vision and deformity of the head and face.^[10] The epidemiological data for orbital trauma are relatively limited. In the United States, in a 7-year retrospective cohort study of orbital fractures, 15.8% of the patients examined were reported to also have eye injuries.^[11] Based on 28,340 cases of head and face injuries causing hospitalization of patients in the United States, the proportion suffering an open eye injury was 4.65%, and 2.37% had orbital fractures.^[12]

The mechanism of eyeball rupture caused by an orbital fracture is as follows:

- (1) If an external force attacks the eyeball directly and the eyeball can move backward, this force could be released by the fat tissue and spread to the surrounding tissues. If the trauma location is not in front of the orbital or the injured eye is rotated to the side, eyeball rupture may ensue; this is common in blowout fractures and fractures associated with scleral laceration.

Table 3
Binary logistic regression analysis for final light perception.

	OR	95% CI	P
Orbital fracture	3.163	1.189–8.414	.021
Zone of injury	7.115	1.510–33.531	.013
reference category = zone III			
Evisceration	59.580	19.515–181.898	.001

CI=confidence interval, OR=odds ratio.

- (2) When the lateral orbital wall is subjected to a great directly force, zygomatic fractures and a shift of the orbital cavity may occur, or cheekbones could be smashed into the orbital cavity (the orbital-maxillary-zygoma complex fracture or lateral orbital wall comminuted fracture). Due to the restrictions of the internal and external canthus ligament, suspensory ligament and superior transverse ligament, the moving range of the eyeball decreases, and fracture fragments falling into the orbital cavity can cause scleral laceration.^[13]

Statistical analyses of visual function damage caused by orbital fracture are rare. The incidence of vision loss due to orbital fractures ranges from 2% to 93%.^[14–17] We speculate that this difference is related to at least 2 aspects. One is the time of examination of visual acuity after injury. One study showed that in patients with orbital fractures after injury, the visual acuity decrease in many patients was reversible (95 patients were followed up, and the decrease went from 56.8% at week 2 to 28.4% at 6 months).

In 363 cases of orbital fractures, 1 week after injury, 90% (329/363) of the patients had vision loss, but at 2 years after injury, vision loss was present in only 17% (62/363).^[18] We found that many reports in the literature do not mention the time of visual acuity after injury, so it is not surprising that the results are very different. Some cases of orbital fracture may be combined with corneal abrasion, transient intraocular hypertension, traumatic mydriasis, traumatic iridocyclitis, anterior chamber hemorrhage, and mild vitreous hemorrhage.^[19] These could cause an early decrease in visual acuity after injury, and such injuries tend to be reversible. The second reason is that the doctor who had examined the patient may not have been an oculist. The ophthalmologic examination requires highly specialized techniques. Much of the literature on orbital fractures was not written by ophthalmologists, so these “nonspecialists” may ignore some ophthalmic signs, resulting in deviations in the examination results. From an analysis of these literature, we found that these “nonspecialist” doctors often record lower rates of eye injury when evaluating the visual function of patients.^[6,20]

Orbital fracture can lead to a variety of eye injuries, such as retinal concussion, retinal detachment, vitreous hemorrhage, choroidal rupture, lens injury, uveal prolapse, and iris ciliary body damage.^[1]

After orbital fracture, injury to the pupil is likely due to an indirect effect of the external force, which causes damage due to the injury of the iris tissue. The joints of the root of the iris and ciliary body are relatively weak; thus, when the orbital fracture causes a contusion to the front of the eye, the aqueous humor displaces a backward pressure to the iris, which may cause iridodialysis. A small area of iridodialysis is usually without symptoms; larger areas result in visual confusion or monocular diplopia.^[21]

When a strong external force is applied to the supraorbital margin, it can result in a comminuted fracture. The force is transmitted to the lens indirectly by the aqueous humor or by a counterforce from the vitreous, which can cause lens concussion, metabolic disorders of the lens capsule and epithelial cells, osmotic pressure increases, and lens opacity. When a strong external force is applied on the lateral wall of the orbital to cause a fracture, the fracture fragments enter the orbit of the eye, and the eyeball is rapidly expanded. After the removal of external force, due to the rebound in lens before and after oscillation, zonules can be pulled off, which can cause lens dislocation.^[22]

When the orbital fracture may lead to the rupture of the retinal and choroidal vasculature, blood flow into the vitreous cavity can cause vitreous hemorrhage. The influence not only is the transparent turbidity of vitreous body and decreased visual acuity but also brings about blood degradation products, inflammatory cells, and inflammatory mediators of the vitreous body and retina. These may induce cell proliferation, which may influence the visual function.^[23]

Although the choroid is thicker than the retina, its toughness is poor, and its tolerance to external blunt force is not as strong as that of the retina. Choroidal rupture can be divided into 2 types: direct or indirect rupture. Direct choroidal rupture occurs at the site of injury, with an external force acting on part of the eye, which makes the wall of the eyeball invaginate. The poor elasticity of the choroid cannot tolerate this powerful instant pressure, which results in choroidal extreme expansion and rupture.

Indirect choroidal rupture results from impacts to the front of the eye that change the shape of the eyeball and the force is transferred to the opposite side wall of eyeball. The choroid must withstand not only the sharp impact force but also the impact of the hard scleral rebound; if not, a choroidal rupture occurs. In addition, the eye is affected by the impact of deformation at the site where the extraocular muscles, optic nerve, and posterior ciliary artery are associated with the eyeball. This will make the pressure of the intraocular pressure increase and cause local choroidal rupture or tear.^[24]

When the orbital is hit by a blunt force, the eyeball is also affected, which results in both an impact injury and a relative impact injury. The retina may also be damaged, with the manifest including a sudden loss of vision and posterior pole retinal edema. Mild traumatic retinal edema, also known as a concussion of the retina, continues to subside for several weeks. If no significant morphological changes occur in the fundus examination, the visual acuity can be restored to normal. Severe traumatic retinal edema, also referred to as retinal contusion necrosis or post-traumatic pigmented retinopathy, may occur. The morphological changes of the retinal pigment epithelium, retinal degeneration, and atrophy can result in a permanent visual impairment.^[25]

Previous reports^[26] have suggested that the best prognosis is found for closed ocular injury. In an open eye injury, the prognosis of a perforating injury is better than that of rupture. However, there are only few reports on orbital fracture combined with ocular trauma, and the research on orbital fracture combined with eyeball rupture is scarce. Therefore, in the present study, we made a retrospective analysis of the prognosis of eyeball rupture complicated with orbital fracture. These results showed that compared with a purely eyeball rupture, the prognosis of eyeball rupture with orbital fracture is worse.

Eyeball rupture occurs when a blunt force acts on the eyeball, the intraocular pressure increases, and intraocular pressure causes breakthrough from the inside to outside, thereby tearing the fiber layer wall of eyeball. It may be associated with uveal and retinal laceration and varying degrees of ocular prolapse.^[27] Scleral rupture is often accompanied by extensive composite damage, such as orbit fracture or brain contusion. Serious scleral rupture combined with injury of anterior segment roughly results in the following situations: first, corneal damage, including corneal abrasions, corneal blood staining, corneal full-thickness or nonfull-thickness laceration; second, the anterior chamber hemorrhage, chamber angle contusion, recession of anterior chamber angle; third, iris concussion or riddialysis; fourth,

ciliary body damage; and fifth, lens dislocation, turbidity, or rupture.

Damage to the posterior segment includes the following situations: first, vitreous hemorrhage or prolapse of vitreous body; second, retinal contusion, retinal detachment, or retinal prolapse; third, choroidal hemorrhage, detachment, and rupture; and fourth, optic nerve contusion or avulsion of the optic nerve.

In this study, eyeball ruptures combined with orbital fractures were more involved with zone 3. The result of orbital fracture combined with eyeball rupture showed that the posterior segment involvement is more common.

When the wound is located in zone 3, there are more opportunities for retinal injury and prolapse of vitreous body.^[28] In this study, patients with eyeball rupture combined with orbital fracture had more opportunities for prolapse of the uveal tissue. This situation often results in complicated vitreous retinal injury.

Rupture of eyeball wall frequently occurs in the weak position of wall of eyeball due to the influence of the limbus, and the insertion zone of rectus often extends to an extreme extent. Rupture of the limbus can cause the intraocular contents to prolapse; when the vitreous body prolapses out, retinal traction from the ora serrata dialysis will easily occur. In severe cases, retinal prolapses result in further wounds and impaction at the rift.

The insertion point of the scleral and rectus muscles is easily damaged during rupture, either backward or at both ends of the extension. This results in damage to the retina via a direct tear force and in both vitreous prolapse and retinal impaction on the wound zone.^[29] At the same time, the intraocular pressure instantly decreases when the eyeball ruptures; this can easily lead to explosive choroidal hemorrhage and may cause severe vitreous retinal prolapse.

Although our data suggested orbital fracture patients most likely had their wounds in zone 3, the regression analysis indicated correlation between orbital fracture and the wound locations. The regression analysis also suggested there was a statistical significant correlation between orbital fracture and light perception measured at the last observation point. Orbital fracture could potentially be an independent variable in determining the prognosis of visual function.

Due to limited funding and manpower, the validity and credibility of the study is somewhat limited. In addition, we only analyzed data on patients with eyeball rupture. We did not perform analysis on closed ocular trauma and different types of orbital fracture such as the fracture of medial orbital wall or the fracture of inferior orbital wall.

Nevertheless, our study showed there is a statistical significant difference between different groups in terms of the wound locations, the present of light perception and uveal prolapse, and the amount of evisceration in the eye. These data may explain that eyeball rupture with orbital fractures is a more serious type of ocular trauma that may have a worse prognosis.

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