

Perforating ocular trauma due to shotgun pellet - Clinical profile and visual outcome

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Purpose: The aim of this study was to determine visual and anatomical outcome of perforating injuries due to shotgun pellet. **Methods:** This was a prospective observational study carried out between July 2016 and Jan 2019 at a tertiary care referral center in Srinagar, Jammu and Kashmir. A total of 172 eyes with perforating injuries of 170 patients were included in the study and were followed up for 6 months with best-corrected visual acuity, slit-lamp examination for status of anterior chamber and lens, fundus examination for status of retina and media, intraocular pressure measurements, and OCT (optical coherence tomography) and FFA (fundus fluorescein angiography) in selected cases. The relative improvement of visual acuity after treatment was interpreted by applying paired two-tailed *t* tests. Prognostic significance of other variables was calculated using Chi-square and Chi-square for linear trend tests, for two dependent outcome variables of good outcome and poor outcome. **Results:** WHO category 4 visual impairment was found in 66 (38.4%) eyes, whereas category 0 was found in 24 (14%) of eyes. Retina was found to be attached 99 (57.6%) of study eyes. **Conclusion:** Perforating injury is a severe form of ocular trauma with grave consequences in terms of functional and anatomical outcome.

Key words: Ocular trauma, perforating injury, shotgun pellet

The American Medical Association's "Guide to the Evaluation of Permanent Impairment," rates permanent impairment to the visual system on an almost equal rate of impairment as to the "whole man" ("a total loss of vision in one eye equals a 25% Impairment of Visual System and a 24% Impairment of Whole Man").^[1] Ocular trauma constitutes a major and preventable cause of ocular morbidity and is a leading cause of monocular blindness.^[2] There has been a gradual increase in the frequency of ocular war injuries from 2% in the Second World War to 7% in the Arab-Israel conflict.^[3] According to BETT^[4] (Birmingham Eye Trauma Terminology) perforating injury is defined as injury with an entry and exit wounds both caused by the same agent. Ocular shotgun injuries represent a small subset of ocular trauma and occur with low frequency. Pellets as cause of injury are unique in that they cause mostly perforating injuries which have worse prognosis than other types of ocular injuries. Morris *et al.*^[5] reported that in 22 patients with perforating shotgun injuries, 43% had a final vision of no light perception. The ability of shotgun pellets to perforate or damage the globe depends on the energy with which they strike the globe. This, in turn, is related to many different factors, including distance, temperature, powder load, shot size, shot weight, and gauge. Velocity decreases with increasing range and decreasing size of shotgun pellets. Number 6 shot (3 mm) fired from a 12-gauge shotgun has a muzzle velocity of 394 m/s and will penetrate a block of 20% ballistic gelatine to a depth of 5 cm when fired from a distance of 30 m (E. I. Herring, Remington Arms Co, written

communication, April 17, 1989). In a review of experimental studies, DeMaio concluded that the critical velocity for penetration of human skin by an air gun pellet was between 38 and 70 m/sec (125–230 ft/sec).^[6] This explains, in part, the ability of shotgun pellets to perforate the eye at close range. First used in response to the civil unrest in Northern Ireland in the 1970s, use of pellet guns in Kashmir (India) to control protesting mobs has emerged as a significant cause of ocular morbidity in this part of world over the last few years. Egypt, South Africa, Israel, and Argentina are other countries that use pellets for crowd control. In addition, pellets are also used worldwide for hunting, pest control, recreational shooting, and competitive sports. The high number of shotgun ocular trauma cases to our emergency department over the past decade prompted this study. Advancing from enucleation, once a standard management for severe ocular trauma, this time period has also seen revolutionary advances in the surgical management of ocular trauma: vitrectomy surgery; endolaser and endoscopy; use of the intraocular gases, heavy liquids, and silicone oil and increasingly sophisticated micro-instrumentation; broad-spectrum antibiotics and anti-inflammatory agents; and many others. These interventions have improved globe survival and functional outcome of such injuries significantly. We sought to determine the prognosis of such injuries in view of modern microsurgical techniques.

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Methods

The study was carried out in complete agreement with the Declaration of Helsinki.^[7] It was a prospective observational study carried out at a tertiary eye care hospital. The duration of study period was one and half year and was carried out between July 2016 and January 2019. Of 643 patients who reported with ocular trauma due to pellet during this period, 172 eyes with perforating injuries of 170 patients were included in the study. Patients with a previous history of surgical intervention or trauma or any ocular disease which may affect the visual outcome like glaucoma, cataract, hereditary fundus disorders, retinal detachments, diabetic or hypertensive retinopathy, ARMD (age-related macular degeneration), retinal vascular occlusion, corneal dystrophies, corneal scars, keratoconus, etc., were excluded from the study. Patients with ocular injury due to causes other than shotgun pellet or with closed globe injury were also excluded from study.

After brief history taking all the patients did undergo the following examination and investigations for both eyes in that order: Visual acuity testing, swinging flashlight test for presence or absence of RAPD (relative afferent pupillary deficit), slit-lamp examination, fundus examination when permitted by media, CT (Computed tomography) scan for detection and localization of foreign body. Detailed history was taken once primary repair was done and once the patients were stabilized and multisystem injury was excluded. As it is known that diagnosis of perforating ocular trauma cannot be made definitively on clinical and imaging findings, some of cases were excluded after primary repair and others based on intra-operative findings of vitreo-retina surgery. Any patients with preexisting ocular condition that may affect visual outcome were also excluded. B-Scan was also done after primary surgery.

At the time of initial evaluation injuries were classified in accordance with BETT (Birmingham Eye Trauma Terminology),^[8] terminology system as open globe and closed globe. Injuries where diagnosis of open and closed globe injury was in dilemma were grouped as suspected open globe injury as suggested by bullous subconjunctival hemorrhage, shallow anterior chamber, ocular hypotony, pupil peaking, loss of red reflex, CT evidence of intraocular aerocoeles, vitreous hemorrhage, and contour flattening. To arrive at definite diagnosis of type of injury these eyes did undergo surgical exploration under microscope and primary repair was carried whenever open globe type was found. Based on clinical, computed tomography and intraoperative findings, perforating injuries were differentiated from rest of open globe injuries.

Almost all primary repairs were performed within 24 hours of injury with intravitreal vancomycin and ceftazidime and subconjunctival dexamethasone to combat against Gram-positive infections, Gram-negative toxins, and inflammation, respectively. All these were also put on oral prednisolone (Unless contraindicated) 1 mg/kg body weight till secondary surgery was undertaken after which the dose of steroids was tapered. Patients were also put on oral Proton Pump Inhibitors and antibiotics (Ciprofloxacin 500 mg twice for 5 days).

Patients were followed up at 1 week, 1 month, 3 months, and 6 months from time of injury. The following examination

and investigations were done at each follow-up best-corrected visual acuity, slit-lamp examination for status for anterior chamber and lens, fundus examination for status of retina and media, intraocular pressure measurements, and OCT (optical coherence tomography) and FFA (fundus fluorescein angiography) in selected cases.

The data were analyzed using standard statistical methods. Categorical variables were summarized as frequencies and percentages, whereas continuous variables as mean and SD (standard deviation). The relative improvement of visual acuity after treatment was interpreted by applying paired two-tailed *t*-test. Prognostic significance of other variables was calculated using Chi-square and Chi-square for linear trend tests, for two dependent outcome variable of Good outcome (defined here as BCVA of 3/60 or better) and Poor outcome (defined here as BCVA of worse than 3/60).

Results

The mean age of patients was 21.9 ± 5.63 years with a range of 10–47 years. Majority 94 (55.3%) of patients were in the age group of 17–22 years as shown in Fig. 1. Almost all 168 (98.9%) our patients were males and only 2 (1.1%) were females. In terms of laterality, 168 (98.8%) patients had only one injured with almost equal rate of right and left eye involvement and 2 (1.2%) patients had bilateral ocular trauma [Fig. 1].

Tables 1 and 2 depict clinical findings of study eyes at presentation. Most common clinical features at presentation was vitreous hemorrhage in 143 (83.1%) followed by hyphema in 124 (72.1%) of study eyes. Majority that is in 117 (68%) of eyes had vitreous prolapse with or without uvea as tissue in wound [Table 2]. Zone of injury, described as posterior most extent of injury in OTC (Ocular Trauma Classification), was Zone III for all eyes, whereas type of injury was perforating (Type D) in all eyes. In our study we observed 3 (1.7%) cases of endophthalmitis. Visual acuity at presentation was found to be in range of 4/200 to light perception in majority (135) eyes. Of these 135 eyes 66.7% had final Snellen visual acuity worse than 3/60.

105 eyes underwent two surgeries including primary repair and VR surgery, whereas 15 eyes entry wound was either not approachable or not localized only vitrectomy was performed. 52 eyes underwent multiple VR surgeries. Chorio-retinectomy was done for exit wounds with adequate endolaser for the margins. In two cases where exit wound was leaking silicone oil, silicone gel foam was used to plug the wound. Postoperative complications requiring re-surgery was RD in 33 (19.1%) eyes, vitreous hemorrhage in 11 (6.4%), PVR in 14 (8.1%), whereas cataract developed in 9 eyes post first vitreo-retinal surgery (VR surgery). After second vitrectomy RD was most common complication. Days of hospital stay ranged from 1 to maximum of 22 days with a mean of 6.16 ± 3.38 days.

At the end of 6-month follow-up, WHO category 4 (Blindness) visual impairment was found in 66 (38.4%) eyes at 6-month follow-up, whereas no or mild visual impairment (Category 0) was found in 24 (14%) of eyes. Visual outcome of 3/60 or worse (mono-ocular blindness) was found in 109 (63.4%). Most significant variable to predict visual outcome was found to be grade of injury (visual acuity at presentation).

Table 1: Clinical features at presentation

	Frequency (n)	Final VA >3/60 (%)	Final VA <3/60 (%)
Anterior chamber findings			
Hyphema	124	38 (30.6%)	86 (69.3)
Traumatic cataract	26	16 (61.5)	10 (38.5)
Lens matter in AC	4	1 (23)	3 (75)
Iridodialysis/iris lacerations	15	5 (33.3)	10 (66.6)
Endophthalmitis	3	0	3 (100)
Tissue in wound			
Uvea prolapse	16	4 (25)	12 (75)
Vitreous prolapse	62	24 (38.7)	38 (61.3)
Retinal tissue prolapses	1	1 (100)	0
Uvea with vitreous prolapse	55	19 (34.5)	36 (65.5)
Posterior segment findings			
Vitreous hemorrhage	143	53 (37)	90 (63)
Vitreous incarceration	56		
Necrotic retina	7		
Subretinal hemorrhage	81		
Retinal detachment	30	2 (6.6)	28 (93.3)

Table 2: Clinical features at presentation

	Frequency (n)	Final VA >3/60 (%)	Final VA <3/60 (%)
Entry wound location			
Cornea and limbus	69	13 (18.8)	56 (81.2)
Limbus to 5 mm of sclera posteriorly	61	23 (37.7)	38 (62.3)
Outside 5 mm behind limbus	42	21 (50)	21 (50)
Exit wound location			
Optic disc	11	1 (9)	10 (91)
Juxta optic disc	31	11 (35.4)	20 (64.5)
Macular	27	4 (14.8)	23 (85.2)
Juxta macular	21	5 (23.8)	16 (76.2)
Equatorial retina	33	20 (60.6)	13 (39.4)
Peripheral retina	20	13 (65)	7 (35)
Not documented	29	7 (24)	22 (76)
Grade of injury			
Grade A (VA 20/40 or better)	2	2 (100%)	0
Grade B (VA 20/50-20/100)	9	8 (88.9%)	1 (11.1%)
Grade C (VA 19/100-5/200)	12	8 (66.7%)	4 (33.3%)
Grade D (VA 4/200-LP)	135	45 (33.3%)	90 (66.7%)
Grade E (VA No LP)	14	0 (0%)	14 (100%)

Of 149 eyes with Grade D or E visual acuity at presentation, 104 eyes (69.8%) had final visual acuity of 3/60 or worse. Visual outcome of study eyes is shown in Fig. 2.

Morphologically normal status of retina was found in 99 (57.6%) of study eyes. Retinal detachment (RD) was present in 51 (29.7) eyes at 6 months of follow-up. These eyes underwent multiple vitreo-retinal surgeries and could not benefit with any further intervention. Table 3 shows anatomical outcome of study eyes. Pthisis bulbi was found in 33 eyes (19.2%). Clinical feature most commonly associated with pthisis bulb (33 eyes) were grade D and E of injury at presentation (30 eyes), cataract (20 eyes), endophthalmitis (3 eyes), vitreous

prolapse (23 eyes), uveal prolapse (18 eyes), multiple surgeries 3 or more (21 eyes), PVR (21 eyes), Aphakia (15 eyes) and recurrent RD (15 eyes).

Discussion

There have been several reports on penetrating eye injuries due to pellet guns that operate on pressurized air.^[8-15] To our knowledge, there are very few studies related to powdered pellet guns. Although some researchers never recorded endophthalmitis after open globe injury due to the characteristic high temperature and speed with which pellets travel, Kara *et al.* did establish in their study that shotgun wounds can be

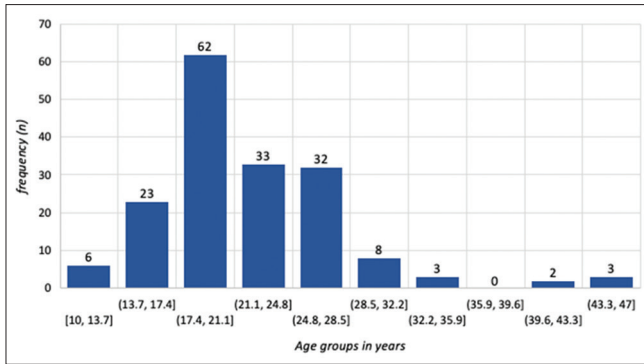


Figure 1: Histogram of Age Distribution of Patients

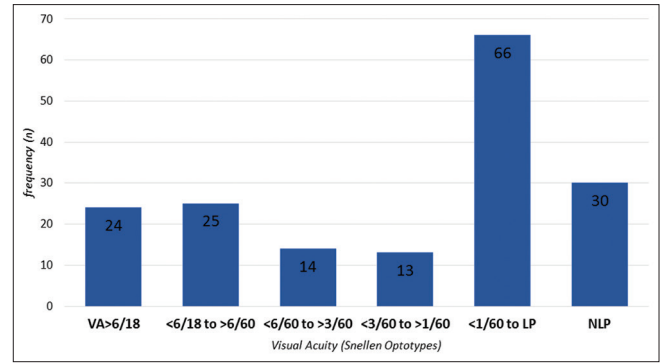


Figure 2: Visual outcome (WHO categories of visual impairment)

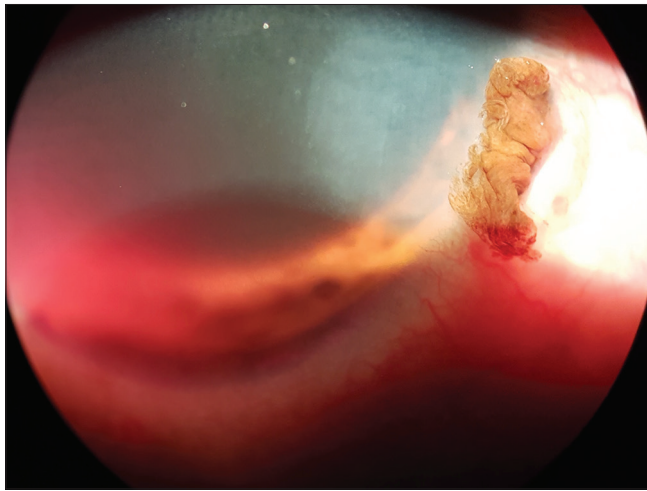


Image 1: Limbal entry wound with prolapse of iridial tissue (at presentation)

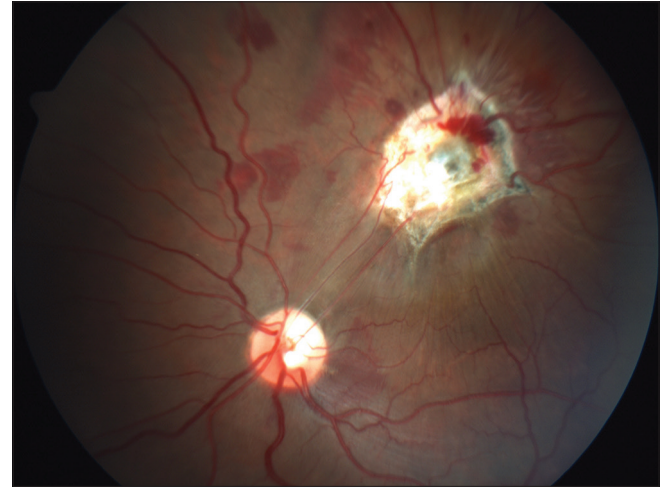


Image 2: Macular exit wound (first postop day)

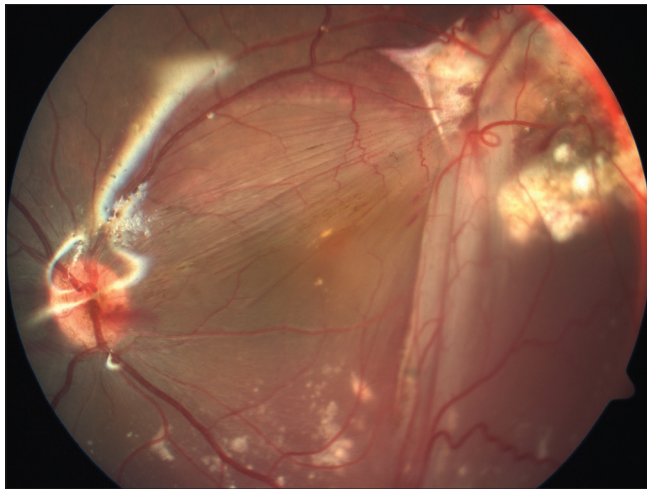


Image 3: Tractional retinal detachment (3 weeks postop)

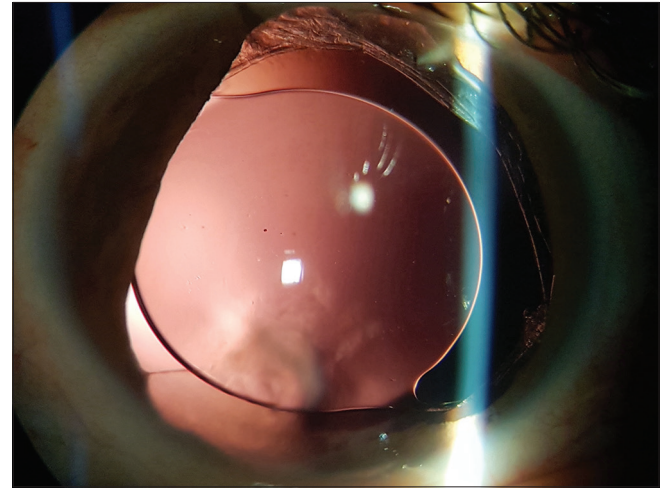


Image 4: Scleral fixated intraocular lens implant

infected by micro-organisms.^[16] This fact was confirmed when other authorities substantiated the fact that some bacteria can resist high-velocity bullets.^[17,18] Organisms frequently found in traumatic globe injuries include *Bacillus cereus*, *Staphylococcus*, and *Polymicrobes* according to Fulcher *et al.*^[19] In our study, we observed 3 (1.7%) cases of endophthalmitis. This rate is lower than that of report by Tabatabaei SA, *et al.*^[20]

The Main Goals of Secondary Vitreoretinal (VR) Surgery are to- 1) remove as much vitreous as possible to clear the globe of the scaffold for fibro-vascular proliferation, with special attention to the trans-vitreous tract between the entry and exit wounds, and the vitreous attachments to the wounds, 2) remove vitreous hemorrhage, which is the most important risk factor for subsequent proliferative vitreoretinopathy (PVR),^[15,21] and 3) reattach the retina. In our center, all these eyes underwent 23G

Pars Plana Vitrectomy with Pars Plana Lensectomy in 66 eyes during first VR surgery and in 5 eyes during second VR surgery. As vitreous hemorrhage and perforation were the most common posterior segment findings, it was logical to perform these procedures. Additional procedures like endo-photocoagulation around exit wounds/breaks and impact sites of FB in 121, retinectomy of incarcerated retina in 4, use of gel foam to prevent leakage of vitreous substitute from exit wound in two eyes and other procedures were done when indicated.

Gas or silicone oil tamponade is recommended for perforating injuries. Silicone oil is the preferred agent for eyes at high risk of developing proliferative vitreoretinopathy. The Silicone Oil Study found that in the management of severe proliferative vitreoretinopathy, silicone oil was superior to SF₆,^[22] and equivalent to C3F₈ in eyes without previous vitrectomy.^[23,24] In our study silicone oil was used in 77 (44.7%), C3F₈ gas in 8, and SF₆ gas in 36. 20.7% (16) eyes developed proliferative vitreoretinopathy after vitrectomy with silicone oil injection and only 16.6% (6) eyes had proliferative vitreoretinopathy formation after vitrectomy with SF₆ gas. The overall rate of proliferative vitreoretinopathy after vitrectomy in our study was found to be 26.16% (n = 45). This frequency was reported by Doheny Eye Institute^[25] in their series of 71 patients to be 43% for perforating injuries. Other studies have reported rates of proliferative vitreoretinopathy after vitrectomy for perforating injuries to be as low as 14%,^[26] to as high as 62%.^[27]

The most common clinical features observed in our study were vitreous hemorrhage followed by hyphema. Majority of clinical findings in our study were found statistically significant in predicting final visual outcome in open globe injury. The most significant findings adversely affecting final visual outcome are shown in Tables 1 and 2. This is in agreement with various previous studies. What was not taken into consideration in other studies to our knowledge is association of location of entry wound in perforating injuries. We found perforating injuries with entry wound located in Zone I (cornea and limbus as shown in image 1) had worse prognosis (81.2% of 69 such injuries had final visual outcome of worse than 3/60) than that of perforating injuries with entry wound in Zone III (50% of 42 such injuries, *P* Value = 0.0005). It may be due to the higher number of macular and juxta macular exit wound location in such injuries as in image 2.

In 146 eyes foreign body was located in intraconal compartment of orbit by computed tomography which together with other radiographic features of open globe injury can detect

perforating nature of injury with significant accuracy. One of the patients had pellet lodged in brain parenchyma which is believed to have traveled there via chip fracture in lateral orbital wall. At the end of 6-month follow-up we did not detect any ocular or systemic manifestation of lead toxicity. Perhaps longer follow-up spanning over decades is needed to detect these manifestations.

We attempted to compare and stratify our study subjects into the same scoring system and study score in our series was very much comparable to the international ocular trauma score (OTS) system as seen in Table 4. In most of the table, there was almost complete agreement between OTS in our study with USEIR (the United States and Hungarian Eye Injury registries) OTS.

Mean initial visual acuity of all eyes in decimal notation changed from 0.054 ± 0.1 (~6/120) to 0.124 ± 0.8 (~6/48) posttreatment that is a change of + 0.07. This change is little more than the change of -0.05 logMAR observed by Tabatabaei *et al.*, in their report of 111 eyes.^[19] There was almost twofold increase in posttreatment mean visual acuity from pretreatment value. Visual acuity at presentation was found to be prognostically significant in predicting outcome as can be concluded from Table 2.

Conclusion

At the end of our study, it can be concluded that perforating injury is a severe form of ocular trauma with grave consequences

Table 3: Anatomical outcome in study eyes

Anatomical outcome	Frequency (n)	Percentage
Corneal opacity	44	25.5
Band shaped keratopathy	5	3
Glaucoma	10	5.8
Hyphema	1	0.5
Pseudophakia (Image 4)	7	4
Aphakia	70	40.6
Foveal distortion	23	13.4
Cataract	20	11.6
Retinal detachment (Image 3)	51	29.7
Retinal breaks	19	11
Proliferative vitreoretinopathy	45	26.2
Phthisis bulbi	33	19.2

Table 4: Analysis of USEIR OTS v/s OTS of our study

OTS score	Raw points	Cases		>20/40 (%)	20/200-20/50 (%)	1/200-19/200 (%)	LP/HM (%)	NLP (%)
1	0-44	13	Study	0	0	0	3 (23)	10 (77)
			USEIR	1	2	7	17	73
2	45-65	139	Study	14 (10.1)	21 (15.1)	28 (20.1)	57 (41)	19 (13.7)
			USEIR	15	13	18	26	28
3	66-80	18	Study	6 (33.3)	5 (27.7)	3 (16.7)	3 (16.7)	1 (5.5)
			USEIR	44	28	15	11	2
4	81-91	2	Study	2 (100)	0	0	0	0
			USEIR	74	21	2	2	1
5	92-100	0	Study	0	0	0	0	0
			USEIR	92	5	2	1	0

in terms of functional and anatomical outcome. Our results suggest that vitreoretinal surgery can offer good visual rehabilitation in patients with shotgun eye injuries. The timing and technique of the primary repair and subsequent need for multiple vitreoretinal procedures may directly affect their anatomical and functional outcome.

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Conflicts of interest

There are no conflicts of interest.

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