Original Article

A series of 777 pellet gun ocular injuries over a 4-month period in Kashmir

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Purpose: To examine the incidence, clinical findings and management of pellet gun–related ocular injuries that occurred during protests in Kashmir region. **Methods:** This retrospective study included records from 777 patients diagnosed with pellet gun–related ocular injuries admitted to a tertiary hospital in Srinagar, India, between July and November 2016. By reviewing the clinical records, the following data were collected: demographics, clinical information pertaining to the injury, imaging reports including computer tomography and ultrasonography B-scan, management in the emergency setting, and follow-up treatment. **Results:** Mean age was 22.3 ± 7.2 years and majority patients were male (97.7%). In terms of laterality, 94.3% and 5.7% of the patients sustained monocular and binocular injuries, respectively. In terms of the nature of injury, 76.3% of the eyes had open globe injury while 23.7% of the eyes had closed eye injury. Emergency surgical exploration was performed in 67.7% of closed globe injuries while emergency primary repair was done in 91.1% of open globe injuries. The vast majority of patients (98.7%) who required surgery underwent surgical intervention on the day of admission or the next day. Final best-corrected visual acuity (BCVA) after treatment was counting fingers or worse in 82.4% of the eyes. **Conclusion:** Pellet gun–related ocular injuries resulted in significant ocular morbidity, mostly manifesting as open globe injuries. Treatment often required surgical interventions, but despite expeditious management, visual prognosis remained poor for most of the patients.

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Ocular trauma imposes significant impact on global health and substantial socio-economic cost to society, due to the need for extensive medical care and vocational rehabilitation, as well as the loss of livelihood and productivity.[1] According to the World Health Organization (WHO), some 55 million eye injuries that limit activities for more than one day occur annually. Approximately 19 million and 3.9 million people are blinded due to ocular injuries in one or both eyes, respectively.[1]

The troubled region of Kashmir has seen a long history of social unrest and military conflict.[2] From July to November 2016, widespread protests and riots as well as clashes between the military and civilian population occurred in Kashmir. Pellet guns were used by security forces against protesters, resulting in significant ocular and systemic injuries.[3] Due to the overwhelming number of victims, ophthalmologists from Mumbai and other parts of India volunteered to attenda tertiary hospital in the region of Srinagar for urgent treatment of casualties.

The study reports the incidence, clinical findings, and management of 777 patients with pellet gun–related injuries admitted for treatment within a short period of 4 months.

Methods

All the patients who had sustained pellet-related ocular injuries and were admitted to a tertiary hospital in Srinagar between July 18, 2016 and November 18, 2016 were included in the study. Patient demographics, clinical records, investigation results, and surgical reports were reviewed. The following data were collected: age, gender, laterality of injury, nature of injury, date of injury in correlation with the date of surgical intervention (if any), duration of admission, best-corrected visual acuity (BCVA), clinical findings, imaging reports including computed tomography (CT) scan of the orbit and ultrasonography (USG) B-scan, management in the emergency setting, and follow-up treatment. The nature of ocular injury was categorized using the Birmingham Eye Trauma Terminology (BETT) system.[4]

The study was approved by the hospital's Institutional Review Board and was carried out in accordance with the tenets of the Declaration of Helsinki.

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Results

A total of 777 patients with a diagnosis of pellet gun–related ocular injuries were included in the study (mean age 22.3 ± 7.2 years; 97.7% male). Fifty-one point one percent (n = 397/777) were aged between 20 and 29 years, with the second highest proportion of patients (36.6%, n = 284/777) aged between 10 and 19 years [Fig. 1].

Data on laterality of the injury was available for 772 patients (data was not available for 5 patients). A majority of the patients (94.3%, n = 728/772) sustained monocular injury. Forty-four patients (5.7%, n = 44/772) sustained binocular injury [Table 1].

Data on the nature of the injury were available for 806 eyes of 762 patients. A total of 615 eyes (76.3%) had open globe injury while 191 eyes (23.7%) had closed globe injury.

In the 728 patients with monocular injury, open globe injury accounted for 74.7% (n = 544/728) [Table 1]. Among the 44 patients with binocular injury, 32 patients (72.7%) had open globe injury in both eyes while 7 patients (15.9%) had open globe injury in one eye and closed globe injury in the other eye [Table 1]. A total of 4 cases of traumatic endophthalmitis was noted.

Best-corrected visual acuity (BCVA) at presentation was available in 742 eyes of 703 patients [Fig. 2]. Eighty-six point seven percent (n = 643/742) of the eyes had a BCVA of counting fingers (CF) or worse, including 5.4% (n = 40/643) of eyes with no perception of light (NPL). Final BCVA after treatment was available in 734 eyes of 697 patients [Fig. 2], with 17.6% (n = 129/734) of the eyes having a BCVA better than 6/60 and 82.4% (n = 605/734) having a BCVA of CF or worse.

Slit-lamp examination findings were available for 473 patients (60.9%) and included corneal abrasion or lamellar laceration in 5 patients (1.1%), traumatic cataract in 126 patients (26.6%), and hyphema in 124 patients (26.2%). Binocular indirect ophthalmoscopy findings were available for 340 patients (43.8%) and included vitreous hemorrhage (VH) in 223 patients (65.6%) and retinal detachment (RD) in 11 patients (3.2%) [Table 2].

CT scan of the orbits was performed in 662 patients (85.2%). Intraorbital foreign body was reported in 415 patients (62.7%), while intraocular foreign body (IOFB) was detected in 180 patients (27.2%). Two hundred four patients (33.8%) had VH on CT scan [Table 2].

USG B-scan was performed in 151 patients (19.4%) with detection of VH in 124 patients (82.1%), posterior vitreous detachment in 34 (22.5%), and RD in 32 (21.2%) [Table 2].

Treatment information was available for 167 eyes with closed globe injury and 606 eyes with open globe injury [Table 3].

Management of closed globe injuries

In the emergency setting, among 167 eyes with closed globe injury, 53 (31.7%) were managed conservatively, 113 (67.7%) underwent surgical exploration with or without removal of pellet, and one (0.6%) underwent cataract extraction. Subsequent surgeries were performed in 21 (12.6%) eyes, among which 13 (7.8%) underwent vitrectomy and 5 (3.0%) underwent combined vitrectomy and lensectomy.

Management of open globe injuries

In the emergency setting and among 606 eyes with open globe injuries, 8 (1.3%) were managed conservatively, 552 (91.1%) underwent primary repair with or without pellet removal, 4 (0.7%) underwent evisceration or had auto-eviscerated, 2 (0.3%) underwent emergent vitrectomy, and 40 (6.6%) were transferred to another hospital. Subsequent operations were performed in 382 eyes (63.0%), including 12 (2%) with cataract extraction, 228 (37.6%) with vitrectomy, and 131 (21.6%) with lensectomy and vitrectomy.

Date of admission and initial surgical procedure was available for 601 patients. A total of 529 patients (88.0%) underwent surgical intervention on the same day of admission, while 64 patients (10.6%) had operation on the next day. Mean duration of admission was 3.01 days.

Discussion

The study describes one of the largest case series of patients with pellet gun–related ocular injury occurring within a short

Table 1: Nature of injury in patients with monocular and binocular injury

	Number of patients	Percentage
Monocular injury		
Closed globe	174	23.9%
Open globe*	544	74.7%
Not available	10	1.4%
Total	728	100%
Binocular injury		
Bilateral closed globe injury	5	11.4%
Unilateral open globe injury and fellow eye closed globe injury	7	15.9%
Bilateral open globe injury**	32	72.7%
Total	44	100%

*including 11 eyes with globe rupture or auto-evisceration. **including one eye with globe rupture

Table 2: Clinical and imaging findings

Findings	No. of Patients	Percentage of patients	Modality (n)
Corneal abrasion or laceration	5	1.1%	Slit lamp (473)
Cataract	126	26.6%	
Hyphema	124	26.2%	
Retinal detachment	11	3.2%	BIO (340)
Vitreous hemorrhage	223	65.6%	
Intraorbital foreign body	415	62.7%	CT (662)
Intraocular foreign body	180	27.2%	
Vitreous hemorrhage	224	33.8%	
Globe rupture	25	3.8%	
Vitreous hemorrhage	124	82.1%	B-scan (151)
Posterior vitreous detachment	34	22.5%	
Retinal detachment	32	21.2%	

BIO, Binocular indirect ophthalmoscopy; CT, Computer tomography; B-scan, Ultrasonography B-scan

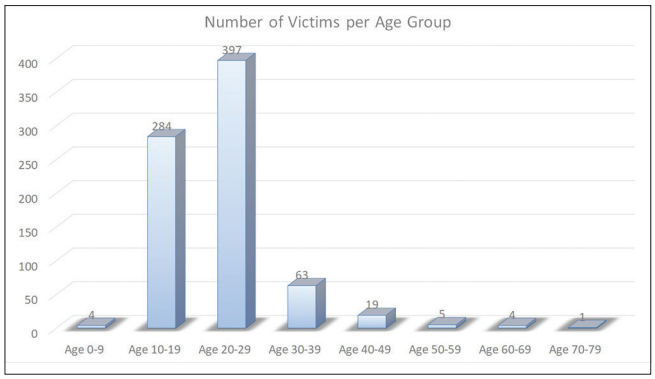

Figure 1: Bar graph demonstrating distribution of number of victims per age group

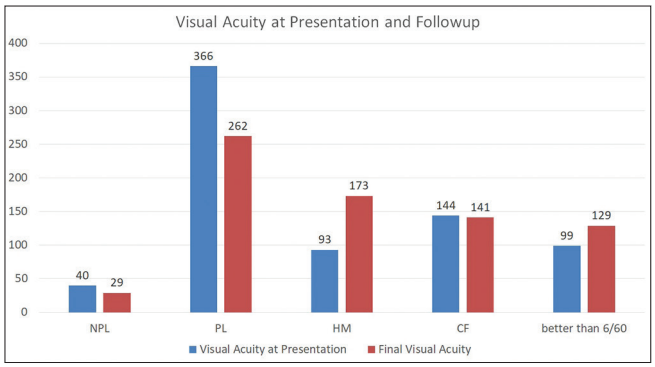

Figure 2: Visual acuity at presentation and postoperatively (NPL, No perception of light; PL, Perception of light; HM, Hand movement; CF, Counting fingers; better than 6/60, Snellen acuity)

period of four months. Compared to the 2010 Kashmir ocular injury study,[5] we included a sample size that is 12 times larger and described a more comprehensive epidemiology of ocular injury with addition clinical information such as slit-lamp examination findings, CT orbital scan and B-scan results, emergency and follow-up treatment, as well as timing of treatment and admission.

Pellet guns are known to cause both life- and sight-threatening injuries. These pump-action guns propel hundreds of small metal pellets, or birdshot, capable of piercing the body and eye.[5–7] A retrospective case series of 36 patients in the USA who sustained injuries from non-powder (ball-bearing and pellet) weapons reported that brain, eye, head, and neck were the most common sites of injury (65.6% of patients).[8] Previous reviews have reported mortality from such weapons, particularly from high-velocity guns. Between 1990 and 2000, the US Consumer Product Safety Commission reported 39 non-powder gun-related deaths.[6] Tabatabaei *et al*.[9] reported 111 cases of pellet gun–related ocular injuries from 2009 to 2013 in one referral center and showed that the final visual outcome was poor even with treatment.

Due to its reported effectiveness and perceived reduced mortality rate compared to traditional guns and weapons, pellet guns have been used to quell mass unrest in Kashmir.[7,10] However, previous studies have described the ocular morbidity associated with the use of such weapons. The 2010 Kashmir study included 60 patients reporting initial BCVA and ocular

Table 3: Treatment summary

Eyes	Closed globe injury		Open globe injury	
	n	%	*n*	%
Emergency setting				
Total	167	100%	606	100%
Conservative	53	31.7%	8	1.3%
Primary repair	-	-	552	91.1%
Exploration	113	67.7%	-	-
Evisceration	0	0%	4	0.7%
Vitrectomy	0	0%	2	0.3%
Cataract extraction	1	0.6%	0	0%
Transfer to another hospital	0	0%	40	6.6%
Follow-up surgery				
Total	21	12.6%	382	63.0%
Cataract extraction	1	0.6%	12	2.0%
Vitrectomy	13	7.8%	228	37.6%
Vitrectomy and lensectomy	5	3.0%	131	21.6%
Others	2*	1.2%	11#	1.8%

*1 eye underwent iridodialysis repair and 1 eye underwent laser retinopexy. # 4 eyes underwent anterior chamber wash; 2 eyes underwent foreign body removal from anterior chamber; 3 eyes underwent silicone oil removal; 2 eyes underwent intraocular foreign body removal and silicone oil infusion

trauma score (OTS). BCVA of HM or worse was noted in 61.6% of eyes, with 83.3% registering an OTS score of 3 or less, predictive of poor visual prognosis.[10] In a series of 105 air gun pellet–related ocular injuries in a civilian setting, 18% ($n = 19/105$) underwent enucleation and 23.8% ($n = 25/105$) had poor vision due to retinal damage, cataract formation, VH, choroidal tear or optic nerve damage.[11] A French study included 160 patients with pellet ocular injury over a period of 5 years, reporting complete disorganization of the eye in 8 eyes, with IOFB and intraorbital foreign body noted in 71 and 23 eyes, respectively.[12] Significant ocular morbidity with poor visual prognosis was similarly reported in our study. More than 80% of injured eyes had an initial BCVA of CF or worse. This statistic improved only slightly to 82.4%, despite expeditious management by the ophthalmologists.

The setting for this review was unique. The intensive period of unrest resulted in an overwhelming number of ocular injuries—three surgeons managed more than 777 patients, conducted more than 550 primary ocular repairs, and performed more than 370 vitreoretinal surgeries. In comparison, 797 cases of severe eye injuries were reported in the war in Iraq from 2003 to 2005, of which 116 eyes were removed.[13] Report from the British armed forces in Iraq and Afghanistan showed a total of 63 cases of ocular injury from 2004 to 2008.[14]

Pellet gun–related ocular injuries are uncommon in the civilian setting in peacetime. An electronic database review of gun–related eye injuries in USA from 1993 to 2002 revealed the decreasing incidence of firearm-related eye injuries, although the rate of air gun–related eye injuries appeared to remain relatively constant. The overall incidence of air gun–related eye injuries was reported at 6 per 1,000,000 patients.[15] One recent study from Finland reported 15 cases of toy gun–related eye trauma in 1 year (2011–2012),[16] while a US tertiary care trauma

center identified 16 cases of open globe injuries from BB gun or pellet gun from 2002 to 2017.[17]

More than 90% of patients included in the study were young males under 30 years old (90.3%). This is an unsurprising statistic, given that most of the protesters in this context were of this demographic. In a similar study on patients with ocular injury during stone pelting demonstration in Kashmir valley in 2010, 75% of the victims were young boys (16–26 years).[10] Nonetheless, young males are more likely to sustain ocular injuries even in the civilian setting. May *et al*.[18] reported that 58% of serious eye injuries were less than 30 years old and the male-to-female ratio was 4.6:1 in the USA. Similar findings were observed in other studies from India[19] and Singapore.[20,21]

Monocular injury accounted for a significant majority (94.3%) of the cases in this study while a small fraction of the population sustained binocular injury. In a 5-year retrospective case series in France, Korobelnik *et al*.[12] reported that 31.9% of a total of 160 pellet gun ocular injury cases were binocular. The higher incidence of binocular injury in this French study might be a result of the circumstance of injury which was the use of pellet gun deliberately during a fight in 85% of the cases. Another French study reviewed 15 years of pellet gun–related ocular injuries and postulated that gun shooting at longer range frequently resulted in binocular trauma due to scatter of pellets, while shooting at close range generated lid, conjunctiva, and powder cornea tattoos.[22]

The majority of the patients in our study had open globe injury. Of these victims, 32 patients sustained binocular open globe injury which carried grave visual prognosis. Due to its high speed and small size, pellets most commonly result in penetrating or perforating globe injury or retained intraocular or intraorbital foreign body. A report on a Kashmir valley demonstration in 2010 showed similar statistics, in which pellets caused 30% of all eye injuries but 50% of all open globe injuries.[10] In another study in the United Kingdom (UK) conducted in a civilian setting, reported incidence of ocular air gun (including pellet guns) injuries was 91 to 115 per year, in which 20% were open globe.[23] In another UK case series of 16 patients, 9 (56.3%) were noted to have open globe injury.[24]

Pellet ocular injury can result in anterior and posterior segment damage. In our study, traumatic cataract, hyphema, VH and RD occurred in 126 (26.6%), 124 (26.2%), 223 (65.6%), and 11 (3.2%) patients, respectively. In a retrospective case series of 33 patients from 1998 to 2002 in Denmark, ocular injuries documented to have occurred from pellet guns included subconjunctival hemorrhage, palpebral hemorrhage, corneal abrasion, hyphema, increased intraocular pressure, iris dialysis, cataract, VH, and retina edema.[25]

Primary repair was the most commonly performed initial surgical procedure in our study. In eyes with open globe injury, about 63.0% required additional procedures including vitreoretinal surgeries. Serious ocular injury poses a significant burden on the medical system. A USA epidemiological study reported that 77% of injured eyes required one or more surgical procedures.[18] In another case series, 9 out of 19 cases with ocular air gun injury required surgery in the emergency setting, mostly primary repair, while 21 operations were performed in total due to ocular injuries.[24]

Although this study focused on ocular pellet injuries, it should be noted that given the nature of the mechanism of injury, patients may require concurrent management of injuries to other parts of the body, which may be life-threatening. A previous case series reported that not just the eye, but also the brain, head, and neck were the most common sites of injury caused by ball-bearing and pellet weapons.[8] Studies have documented pellet injuries concomitant to the ocular injuries, involving the sphenoid sinus,[26] ethmoid sinus,[27] cerebellum,[28] temporal lobe,[29] adjacent to the cavernous sinus[30] and even the heart.[31] Therefore, the management of pellet gun injuries may require the involvement of neurosurgeons, otorhinolaryngologists, and other surgical specialists.

There are limitations to this study. The design of the study can only be retrospective due to the emergency nature of the event in Kashmir. Clinical documentation was not available for all the patients, resulting in incomplete data collection including laterality and nature of the injury, exact location, size and number of pellet foreign body, investigation, and treatment results. This was understandable given this setting of a civil emergency in an area with limited medical resources. The priority of healthcare workers was to provide expeditious, emergency medical and surgical treatment for an overwhelming number of casualties with potentially blinding ocular injuries. Nonetheless, surgeons and staff endeavored to ensure that the clinical documentation was as complete as possible. Moreover, it should be noted that this study does not describe all the ocular injuries (e.g., traumatic optic neuropathy, glaucoma, orbital injuries) or systemic injuries related to pellet gun sustained during this period of conflict in Kashmir. The data collected did not include non-pellet gun–related injuries, patients who presented at other medical facilities, as well as those without access or means to medical care. The complete scope and burden of ocular and systemic injuries during this period of conflict is therefore likely to be more significant.

Our study showed that pellet gun–related ocular injuries resulted in significant morbidity. Further public education and prevention of such injuries may be warranted. The majority of the patients in this study were not using eyewear at the time of their injury, although this information was not objectively documented in the clinical notes. While military eye protective wear is widely utilised in conventional warfare and has been shown to be effective in reducing the extent of injury from ballistic or pellet-related mechanisms,[32] it is unlikely that similar devices can be made available for the wider civilian population given the cost and accessibility of such equipment. Perhaps education on eye protection for civilians in regions where military and security forces are known to utilize pellet guns may be useful in reducing the incidence of such injuries. Improving the accessibility and reducing the cost of protective eyewear may reduce the significant socio-economic cost resulting from ocular injuries.

Conclusion

Pellet guns, although less fatal than traditional ballistic-based weapons, result in significant ocular morbidity. The victims in this study were mostly young males with bilateral eye injuries. The majority of casualties sustained open globe injuries. Surgical intervention was often necessary and despite the expeditious treatment, visual outcomes remained

poor. The poor visual outcomes, high costs of medical care, and long-term visual rehabilitation process in these young working-age patients impose a significant physical, emotional, and socio-economic burden to both individuals and the society. Therefore, prevention is always better than the cure in ophthalmic trauma, and it is strongly advised to avoid the use of pellet guns against civilians.

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Conflicts of interest

There are no conflicts of interest.

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