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Original research

Pellet gun injury as a source of ocular trauma; a retrospective review of one hundred and eleven cases

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Abstract

Purpose: To report the demographic data, treatment methods, and outcomes among patients with pellet gun eye injuries.
Methods: This study was a retrospective review of all pellet gun eye injuries coming to Farabi Eye Hospital, a referral ocular trauma center in Iran, from February 2009 to November 2013. Patients' demographics, type of injury, choice of management, complications, and post-treatment visual acuity were recorded.
Results: One hundred eleven patients with a mean age of 25.7 ± 15.6 years entered the study. The most common age group was younger adults (16–45 years old) (61.3%). The mean uncorrected visual acuity after treatment was 2.05 (20/2240) ±1.5 logMAR. The most prevalent ocular zone was zone III (38.7%), and an intraocular foreign body was present in 97 patients (87.4%). Lid laceration and periocular tissue damage were present in 27 patients (24.3%). Lensectomy and vitrectomy were the most common treatment (31.5%). In most patients (87.4%), the injury was non-deliberate, and the most common time of hospitalization was the same day (45.0%). The only statistically significant indicator of post-treatment visual acuity was ocular trauma score (OTS) at admission ($P < 0.001$). At the end of follow-up, enucleation was performed for 20 patients (18%), and thirty-six patients (32%) had no light perception (NLP) in vision.
Conclusion: Pellet gun injuries were more common among young male patients, and the only statistically significant indicator of post-treatment visual acuity was OTS at admission.

Keywords: Demographic; Eye; Injury; Pellet gun; Outcome

Introduction

Today, various types of air guns are freely available to the public. Kratz et al. suggested that air guns are favorable among children and youngsters due to their low cost, availability, lack of age restriction, and their similarity to real guns.[1] Most children look at these weapons as a toy, and parents think the projectile has very little power of penetration.

Eye injuries, especially among children and young adults, constitute a substantial part of the events related to air guns.[2–4] Based on the United States Eye Injury Registry Database, ball bearing (BB) guns and pellet guns are the most frequent gun injuries in the emergency setting, accounting for nearly 6% of all ocular injuries.[5,6]

According to Shuttleworth et al., air guns have various mechanisms including, pop guns, pellet guns, BB guns, soft air guns, and paintball guns, all of which use compressed air or another form of compressed gas to propel the projectile.[7]

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Pellet guns are one of the cheapest and most widespread air guns. According to Sharif et al., a standard pellet gun bullet weights 0.345 g and enters the globe at average speed of about 72 Meter/Second which has the power to penetrate through the skin, entire globe, and even the orbital bones.[8] Trauma caused by the collision of the pellet gun projectile with the globe and orbit has the potential to cause diverse injuries including penetrating trauma, hyphema, foreign body entrance into the globe and orbit, traumatic cataract, retinal detachment, optic nerve damage, endophthalmitis, and loss of eyesight.

Although BB gun-related injuries have been reported in numerous reports there is a relatively limited number of studies related to pellet gun injuries.[5,7–13] Earlier reports have indicated the severity of this type of trauma and advocated for improving public awareness and encouraging prophylactic measures to reduce their danger.[5,9,14]

The purpose of the present study is to report a large number of pellet gun injuries treated in our center in a 5-year time frame. Patients' demographics, type of injury, choice of management, and treatment outcomes including the final visual acuity are reported.

Methods

Patients

The present study was a retrospective, case series study including all patients with eye injuries caused by pellet gun referred to Farabi Eye Hospital in a five-year period from January 2009 till December 2013. This hospital is in charge of ophthalmic emergencies, covering a large portion of Iran, and also serves as a referral center admitting severe cases of eye trauma from all over the country. The study was approved by the Ethics Committee of Tehran University of Medical Sciences. The required information was obtained through review of patients' medical records. The inclusion criteria were sustaining eye injury caused by pellet gun and being Iranian (several patients from other countries were excluded to keep the consistency of data). The exclusion criteria were history of eye accidents and/or endophthalmitis as well as eye surgery for any reason before the present accident.

Data collection

A special data sheet was designed to retrieve the data from medical records before the start of the study. The information retrieved from patients' records included age, sex, types of pellet gun, the deliberate firing of gun (according to the judicial authorities' opinion), place of residence (Tehran, other big cities, villages, and countryside), the time interval between trauma and patient's referral to hospital, the zone of ocular trauma, the presence of eyelid and periocular tissue lacerations, the presence of foreign body (projectiles) inside the eye [intraorbital foreign body (IOFB)] and the presence of foreign body in the orbit (IOFB), visual acuity at admission to hospital, penetration of the globe, presence of Marcus Gunn pupil, endophthalmitis, eye perforation, and retinal detachment as well as ocular trauma score (OTS). OTS is a good grading system for detecting the prognosis of ocular trauma.[15] Patients with any missing data in each of these variations were excluded from the study.

Also, the method of treatment and treatment outcomes at six months after the treatment were recorded. Patients were divided into three age groups including children (under 16 years old), young and middle aged (16–45 years old), and older patients (more than 45 years old). The OTS scoring system was used to categorize the severity of eye injuries. Patients older than 18 years had received oral ciprofloxacin 750 mg/12 h for three days. Patients under 18 years old had received IV vancomycin 10 mg/kg/day every 6 h and IV ceftazidime 30 mg/kg/day every 8 h for three days.

Compliance with ethical standards

The present study was approved by the Ethics Committee of Tehran University of Medical Sciences. The study was performed in accordance with the ethical standards as laid down in the Declaration of Helsinki. None of the authors has any conflict of interest with the subject matter of the study.

Statistical methods

To present data, we used mean, standard deviation (SD), median, and range. To assess the equality percent of subjects in the different variables, we used one group Chi-square test. To compare the visual acuity between different groups at baseline, we used the Mann-Whitney and Kruskal-Wallis tests, and to evaluate the changes of visual acuity in different groups, we used Wilcoxon-Singed rank test. To compare the final visual acuity between groups when the baseline values were adjusted, we used analysis of covariance (ANCOVA). All statistical tests were performed using SPSS software version 24 (Armonk, NY: IBM Corp.). *P*-value less than 0.05 was considered statistically significant.

Results

In total, 116 medical records of patients with pellet gun injuries who met our inclusion and exclusion criteria were studied. Patients' demographic findings including age, sex, place of residence, time between incident and hospitalization, and the intentional nature of trauma are presented in Table 1. The mean age of patients was 25.7 ± 15.6. Ninety-four patients were male, and 17 patients were female, indicating a statistically significant higher prevalence of pellet gun injuries among male patients ($P < 0.001$). The most common age group was 16- to 45-year-old patients ($P < 0.001$). Most patients were admitted on the same day ($P < 0.001$), and the number of non-deliberate accidents was statistically higher than deliberate shootings ($P < 0.001$).

Table 2 presents patients' findings before treatment including the visual acuity of the injured eye, the ocular zone of injury,[9] presence and severity of Marcus Gunn pupil, the presence of intraocular foreign body and eyelid laceration, the

Table 1
Demographic findings of patients entering the study.

Parameter	Statistics	Value	P^a
Age	Mean ± SD	25.7 ± 15.6	
	Median (range)	22 (2–77)	
Age groups	≤15.0	27 (24.3%)	<0.001
	16.0–45.0	68 (61.3%)	
	46.0+	16 (14.4%)	
Sex	Male	94 (84.7%)	<0.001
	Female	17 (15.3%)	
Place of residence	Tehran	18 (16.2%)	<0.001
	Cities other than Tehran	51 (45.9%)	
	Rural	42 (37.8%)	
Time between incident and hospitalization	Same day	50 (45.0%)	<0.001
	After one day	26 (23.4%)	
	After 2 days	21 (18.9%)	
	After 3 days	8 (7.2%)	
	After 4 days	3 (2.7%)	
	After 5 days	2 (1.8%)	
	After 6 days	0 (0.0%)	
	After a week	1 (0.9%)	
	More than a week	0 (0.0%)	
Intentional or non-intentional	Deliberate injury	17 (15.3%)	<0.001
	Non-deliberate injury	94 (84.7%)	

SD: Standard deviation.
[a] Test for equality of strata, based on Chi-square test.

presence of systemic problems, OTS, as well as the treatment methods. The most common zone of injury in open globe injuries was zone 3, most patients had intraocular foreign body, the most common trauma score was 1, and the most common treatment method was lensectomy and/or pars plana vitrectomy secondary to primary repair. Endophthalmitis was observed in 4 cases (2.7%) at the presentation (from which, 3 cases were bacillus endophthalmitis, and the last one was culture negative. In three cases the final visual acuity was light perception and the case with negative culture had final vision of hand motion. No case of endophthalmitis was added after primary repair and secondary surgeries.

At the end of follow-up, enucleation was performed for 20 patients (18%), and thirty-six patients (32%) had no light perception (NLP). No patient underwent primary enucleation. Table 3 demonstrates the change of visual acuity six months after treatment related to baseline findings. The only statistically significant indicator of post-treatment visual acuity was OTS at admittance ($P < 0.001$) in both multivariate and univariate analysis. As it can be observed in this table, the visual acuity of patients improved significantly regardless of the zone of injury, the presence of Marcus Gunn pupil, lid laceration, and their age group. The presence of foreign body or the

Table 2
Ocular findings before treatment and treatment methods.

Parameter	Statistics	Values	P^a
Visual acuity	Mean ± SD	2.56 (CF 10 cm = 20/7260) ± 1.38	
	Median (range)	2.70 (0.15–3.10)	
Ocular Zone	Intact globe	30 (27.0%)	0.002
	Zone I	22 (19.8%)	
	Zone II	16 (14.4%)	
	Zone III	43 (38.7%)	
Marcus gun pupil	Negative	28 (25.2%)	0.62
	+1	21 (18.9%)	
	+2	19 (17.1%)	
	+3	24 (21.6%)	
	+4	15 (13.5%)	
	Uncooperative	4 (3.6%)	
Foreign body	No foreign body	14 (12.6%)	<0.01
	Intraocular foreign body	14 (12.6%)	
	Intraorbital foreign body (IOFB)	83 (74.8%)	
Periocular laceration	No	84 (75.7%)	<0.001
	Yes	27 (24.3%)	
Ocular Trauma Score (OTS)	1	41 (36.9%)	<0.001
	2	39 (35.1%)	
	3	11 (9.9%)	
	4	4 (3.6%)	
	5	16 (14.4%)	
Treatment methods	Only primary repair	5 (4.5%)	<0.001
	Exploration and/or foreign body removal and/or primary repair	18 (16.2%)	
	Lensectomy and/or anterior vitrectomy	19 (17.1%)	
	Pars Plana vitrectomy and/or foreign body removal	26 (23.4%)	
	Lensectomy and/or Pars Plana vitrectomy	30 (27.0%)	
	Enucleation	20 (18.0%)	
Number of patients in different visual acuity groups	NLP	36 (32%)	
	LP-HM	30 (27%)	
	HM < Visual acuity < 1/10	37 (33%)	
	1/10 ≤ Visual acuity	8 (7%)	

SD: Standard deviation, CF: Counting finger, NLP: No light perception, LP: Light perception, HM: Hand motion.
[a] Test for equality of strata, based on Chi-square test.

Table 3
The change of visual acuity six months after treatment compared to pre-treatment related to baseline findings.

Parameter	Level	n	Pre		Post		Change	
			Mean ± SD	*P*	Mean ± SD	*P*[c]	Mean ± SD	*P* comparison Pre and Post[d]
Visual acuity in all patients		111	2.56 (20/7260) ± 1.38		2.05 (20/2240) ± 1.5		−0.51 ± 1.09	<0.001
Ocular Zone	Intact globe	30	1.22 ± 1.32	0.028[b]	0.96 ± 1.24	0.725	−0.25 ± 0.72	0.006
	Zone I	22	2.72 ± 1.27		2.09 ± 1.44		−0.64 ± 1.29	0.046
	Zone II	16	2.94 ± 0.35		2.46 ± 1.06		−0.48 ± 0.97	0.009
	Zone III	43	3.06 ± 1.02		2.42 ± 1.41		−0.64 ± 1.23	0.001
Marcus Gunn Pupil	negative	28	0.6 ± 0.89	<0.001[b]	0.42 ± 0.58	0.42	−0.19 ± 0.66	0.02
	1	21	2.89 ± 0.96		2.24 ± 1.33		−0.65 ± 1.24	0.018
	2	19	2.92 ± 0.69		2.30 ± 1.31		−0.62 ± 1.17	0.046
	3	24	3.00 ± 0.61		2.50 ± 1.34		−0.50 ± 1.29	0.029
	4	15	3.10 ± 0		2.79 ± 0.83		−0.31 ± 0.96	0.01
	Uncooperative	4	3.10 ± 0		2.83 ± 1.52		−0.27 ± 1.52	0.041
Foreign body	No foreign body	14	1.59 ± 1.49	0.005[a]	1.39 ± 1.67	0.738	−0.21 ± 0.91	0.042
	Intraocular foreign body	14	1.45 ± 1.42		1.44 ± 1.27		0.09 ± 0.01	0.181
	Intraorbital foreign body (IOFB)	83	2.71 ± 1.32		2.15 ± 1.45		−0.55 ± 1.11	<0.001
Lid laceration	No	84	2.73 ± 1.26	0.060[a]	2.20 ± 1.44	0.826	−0.54 ± 1.08	0.001
	Yes	27	2.04 ± 1.62		1.61 ± 1.61		−0.43 ± 1.14	0.006
Ocular Trauma Score (OTS)	1	41	2.58 ± 1.39	0.225[a]	2.06 ± 1.5	0.929	−0.52 ± 1.1	<0.001
	2	39	2.36 ± 1.37		1.93 ± 1.49		−0.43 ± 1.05	0.276
	3	11	2.56 ± 0.34	<0.001[b]	2.15 ± 1.02	<0.001	−0.41 ± 0.95	0.003
	4	4	2.94 ± 0.57		2.05 ± 1.27		−0.88 ± 1.39	<0.001
	5	16	1.13 ± 0.7		0.52 ± 0.27		−0.61 ± 0.81	0.001
Treatment method	Only primary repair	5	0.38 ± 0.26		0.26 ± 0.23		−0.11 ± 0.43	0.564
	Exploration and/or foreign body removal and/or primary repair	18	0.15 ± 0		0.26 ± 0.25		0.11 ± 0.25	0.102
	Lensectomy and/or anterior vitrectomy	19	2.35 ± 1.73	<0.001[b]	2.00 ± 1.76	0.501	−0.35 ± 0.85	0.041
	Pars plana vitrectomy and/or foreign body removal	26	1.05 ± 1.21		0.86 ± 1.16		−0.19 ± 0.66	0.038
	Pars Plana vitrectomy and/or lensectomy	30	3.04 ± 1.073		2.06 ± 1.2		−0.98 ± 1.2	0.157
	Enucleation	20	3.06 ± 0.12		3.10 ± 0		0.04 ± 0.12	0.98
Age groups	≤15.0	35	2.93 ± 0.81		2.08 ± 1.37		−0.85 ± 1.35	<0.001
	16.0–45.0	49	3.00 ± 0.65		2.52 ± 1.1		−0.48 ± 0.9	0.009
	46.0+	27	2.47 ± 1.51	0.449[b]	2.10 ± 1.55	0.149	−0.37 ± 0.78	0.024
Endophthalmitis	4 cases (2.7%)							

SD: Standard deviation.
[a] Based on Mann-Whitney test.
[b] Based on Kruskal-Wallis test.
[c] Adjusted for the baseline, based on Analysis of Covariance (ANCOVA).
[d] Based on Wilcoxon-Signed rank test.

treatment method did not significantly influence the visual outcomes.

Discussion

There have been several reports on penetrating eye injuries due to pellet guns.[5,7–13] To our knowledge, there is no similar report from Iran.

The mean age of our patients was 25.7 ± 15.6, and the most common age group of patients was 16- to 45-year-old. In contrast, in a report of air gun injuries from New Zealand by Langley et al.[2] the most common age group was reported under the age of 14, and in a report of 140 patients with ocular injuries from air guns from the United States by Schein et al., the mean age of patients was only 13 years.[16] Also, in a report of 105 patients with ocular air gun injuries from England by Shuttleworth et al., 74% of patients were under 18 years old with a mean age of 17.5 ± 9.12 years.[7] It seems that the usage of air guns and subsequent eye injuries starts in a relatively higher age in Iran compared to those countries reported above.

Our data indicated a 5.7 to 1 male to female ratio for pellet gun eye injuries which is in line with previous studies reporting higher incidence of these injuries in males.[2,3,7,15,16] Patel et al., in a review of 202 cases of penetrating eye injury have reported a 4.66 to 1 male to female ratio.[3] Bowen et al., in a study of 105 cases with pellet gun injuries from England have reported a 7.5:1 male to female ratio.[12] In a report of 718 cases of air gun injuries from New Zealand by Langley et al.,[2] this ratio was 6 to 1. It seems that the more aggressive nature of males compared to females as well as the higher popularity of air guns among men both as a toy or hunting weapon can describe the statistically higher number of injuries among the male population.

We found that about half of our patients were from urban and the other half from rural communities. In contrast to our findings, this ratio has been reported to be 5 to 1 urban to rural communities in New Zealand. The difference might be due to the report from New Zealand being relatively old, covering patients from 1979 to 1992 which might explain less availability of air guns in rural communities during the time of their study. It might also be related to the difference between the urban and rural population distribution between Iran and New Zealand.[2]

Most of our patients were admitted on the same day. Similarly, Shuttleworth et al. have reported that excluding two outliers with very delayed presentations, the vast majority of their patients suffering from ocular air gun injuries were presented immediately following their injury (mean 0.31 days, SD 0.79).[7]

The number of non-deliberate accidents in our study was statistically higher than deliberate shooting with 17 patients out of 116 cases (14.6%), which is similar to several other studies. Shuttleworth et al. have reported that 65 of their cases were accidents, while only 19 cases were deliberate shootings.[7] Also, out of 718 air gun-inflicted incidences in New Zealand reported by Langley et al., only 6 cases were intentional (6%).[2] The mostly non-intentional nature of these costly injuries emphasizes the importance of public awareness and publicizing the risks associated with air guns.

The pre-treatment logMAR of the injured eye among our patients was 2.56 ± 1.38 which improved to 2.05 ± 1.5 six months post-treatment, indicating a statistically significant improvement. In the study by Shuttleworth et al. on patients with air gun eye injuries, the mean visual acuity at presentation was 1.23 ± 1.05, which improved to 0.81 ± 1.25, indicating a significant improvement.[7] It should be noted that their study included all kinds of air guns which might explain their better overall visual outcomes either at presentation or after treatment. When reporting those patients injured by pellet guns, their results indicated a mean visual acuity of 1.79 at presentation which is more similar to our presenting visual acuities.[7]

In our study, foreign body was present in 97 out of 116 patients (83%). This was reported to be 50% in a study by Khoueir et al.[5] reporting the results of vitreoretinal surgery for pellet gun eye injuries and 75% in the study by Shuttleworth et al.[7] Lensectomy and vitrectomy was our most common treatment method performed on 35 eyes (31.5%). This is in line with the study performed by Khoueir et al., who reported that 50% of their patients needed combined lensectomy and vitrectomy.[5] Also in the present study, the most common zone of injury was zone 3 which we think is due to ballet being stopped after collision with the posterior globe.

In our study, the only variable that showed a statistically significant influence on post-treatment visual acuity was the initial OTS, worse trauma scores was associated with worse visual acuity. Although it has been proposed that zone of the injury and Marcus Gunn pupil could be a prognostic factor in ocular trauma,[15,16] in our study, the only prognostic factor was OTS. It may be related to the characteristics of ocular trauma in pellet gun injuries that involves many structures in the eye or related to a small sample size in our cases. It is obvious that in OTS different separate items are included.

The presence of foreign body or the treatment method did not significantly influence the visual outcomes. Although our sample size was respectable in comparison with similar studies, it might not be adequate to reliably establish the risk factors influencing the final visual acuity among pellet gun victims, so further studies including bigger sample sizes are suggested.

Unfortunately, no license is required for an air gun or air pistol in Iran, and they are readily available for purchase. Although the law could be changed to provide further restrictions, this would probably not totally prevent the use of such weapons. It seems that the most successful way of reducing eye injuries by air guns is publicizing their risks and improving the public awareness. A main shortcoming of the present study was that it was conducted among patients coming to a referral center in the capital city of Tehran. It is a known fact that many of our patients were those with a more serious injury who were deemed to be hard cases and subsequently referred to our center. This fact might imply that our findings regarding the seriousness of injury and low visual outcomes might be worse than the normal average among patients.

In conclusion, our results suggest that pellet gun injuries are more common among young male patients, and the final visual outcome after treatment is poor. The most common treatment was lensectomy and vitrectomy, and the only statistically significant indicator of post-treatment visual acuity was OTS at admission.

References

1. Kratz A, Levy J, Cheles D, Ashkenazy Z, Tsumi E, Lifshitz T. Airsoft gun-related ocular injuries: novel findings, ballistics investigation, and histopathologic study. *Am J Ophthalmol*. 2010;149(1):37–44.
2. Langley JD, Robyn NN, Alsop JC, Marshall SW. Airgun injuries in New Zealand, 1979–92. *Inj Prev*. 1996;2(2):114–117.
3. Patel BC. Penetrating eye injuries. *Arch Dis Child*. 1989;64(3):317–320.
4. Saunte JP, Saunte ME. Childhood ocular trauma in the Copenhagen area from 1998 to 2003: eye injuries caused by airsoft guns are twice as common as firework-related injuries. *Acta Ophthalmol*. 2008;86(3):345–347.
5. Khoueir Z, Cherfan G, Assi A. Vitreoretinal surgery for shotgun eye injuries: outcomes and complications. *Eye Lond*. 2015;29(7):881–887.
6. Dandu KV, Carniol ET, Sanghvi S, Baredes S, Eloy JA. A 10-year analysis of head and neck injuries involving nonpowder firearms. *Otolaryngol Head Neck Surg*. 2017;156(5):853–856.
7. Shuttleworth GN, Galloway P, Sparrow JM, Lane C. Ocular air gun injuries: a one-year surveillance study in the UK and Eire (BOSU). 2001-2002. *Eye Lond*. 2009;23(6):1370–1376.
8. Sharif KW, McGhee CNJ, Tomlinson RC. Ocular trauma caused by airgun pellets: a ten year survey. *Eye*. 1990;4(Pt 6):855–860.
9. Kolomeyer AM, Shah A, Bauza AM, Langer PD, Zarbin MA, Bhagat N. Nail gun-induced open-globe injuries: a 10-year retrospective review. *Retina*. 2014;34(2):254–261.
10. Young DW, Little JM. Pellet-gun eye injuries. *Can J Ophthalmol*. 1985;20(1):9–10.
11. Sevel D, Atkins AD. Pellet gun injuries of the eye. *S Afr Med J*. 1978;54(14):566–568.

12. Bowen DI, Magauran DM. Ocular injuries caused by airgun pellets: an analysis of 105 cases. *Br Med J*. 1973;1(5849):333–337.
13. Al-Amry M, Al-Taweel H, Al-Enazi N, Alrobaian M, Al-Othaimeen S. Retained periorbital and intracranial air-gun pellets causing sclopetaria and visual loss. *Saudi J Ophthalmol*. 2014;28(3):228–233.
14. Shuttleworth GN, Galloway PH. Ocular air-gun injury: 19 cases. *J R Soc Med*. 2001;94(8):396–399.
15. Purtskhvanidze K, Rüfer F, Klettner A, Borzikowsky C, Roider J. Ocular Trauma Score as prognostic value in traumatic ocular injuries due to rotating wire brushes. *Graefes Arch Clin Exp Ophthalmol*. 2017;255(5):1037–1042.
16. Schein OD, Enger C, Tielsch JM. The context and consequences of ocular injuries from air guns. *Am J Ophthalmol*. 1994;117(4):501–506.