Ocular Paintball Injuries

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ABSTRACT: **Background:** One of the most alarming ocular injury trends in recent years has been the proliferation of paintball guns and the proportional increase in the number of ocular eye injuries caused by paintballs.

Objectives: To describe five cases of paintball eye injuries that resulted in loss of functional vision in four of them.

Methods: We conducted a retrospective review of the clinical course in five patients with paintball eye injuries treated in the ophthalmology departments of two medical centers.

Results: Five young males were evaluated for paintball injuries caused by blunt trauma. There was one case of full-thickness laceration (globe rupture). Four patients required one to five surgical interventions: three of these involved the removal of traumatic cataract including two eyes with significant zonular dehiscence treated by lens capsule conservation using anchoring devices, one retinal surgery and two glaucoma filtration surgeries. However, final visual outcome was not favorable due to irreversible retinal damage.

Conclusions: Paintball trauma often results in significant ocular injury and loss of functional vision despite successful surgical intervention. Most injuries occur in under-supervised settings and are easily preventable. Improved safety measures, strict regulation enforcement and appropriate public education could prevent such serious damage.

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KEY WORDS: paintball, ocular injury, paintball eye injury, surgical repair

Paintball is a popular "war game" [1]. The paintballs are 14 mm spherical projectiles containing non-toxic, water-soluble glycerin, polyethylene glycol, titanium oxide and dyes within a gelatin or latex coat [1]. The balls can reach a velocity of 35 to 100 m/sec [2]. Upon impact, the external layer ruptures, releasing the colored liquid to mark the area of impact. Ocular, dermatologic, and sports-related injuries are commonly sustained during the game [3]. Eye trauma due to paintball can range from mild to very severe injuries, which can lead to blindness [4,5]. Following the first reported case of eye injury secondary to paintball projectiles in 1985 [6], organizers of formal paintball "games" mandated and regulated eye protection and education. These precautions led to a substantial decline in the frequency of severe ocular injuries during commercial paintball war games [7]. In recent years, however, reported paintball injuries have increased, attributable to playing in uncontrolled, non-commercial settings in which proper eye protection was not used [5,7].

This case series describes five patients with paintball trauma that included anterior segment and retinal injuries. We also report our experience with preservation of the lens capsule using a capsular anchor in two cases with a subluxated lens.

PATIENTS AND METHODS

We retrospectively reviewed cases of eye injury presenting to two medical centers in Israel from 2001 to 2014. Those in whom the injury was attributed to a paintball were identified and evaluated to determine ocular findings and visual prognosis. Institutional review board approval was obtained. The summary of cases is shown in Table 1.

CASE 1

A 22 year old healthy male was hit in the right eye by a paintball in 2001. He was not wearing protective goggles. Initial examination revealed visual acuity (VA) of hand movement, hematoma of lid, conjunctiva, hyphema, vitreous hemorrhage, giant retinal tear and rhegmatogenous retinal detachment. Vitrectomy and lensectomy were performed and a silicone oil injection was administered.

At the last follow-up, 4 months later, ophthalmic examination revealed VA of hand movement, intraocular pressure (IOP) 6 mmHg, aphakia, silicone oil in the vitreous cavity, scarred retina in the region of the tear, macular detachment and proliferative vitreoretinopathy. The patient was lost to follow-up.

CASE 2

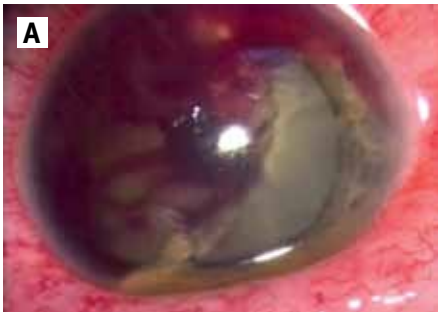
A 19 year old male was admitted in July 2012 due to a paintball injury of his right eye. He played paintball in a licensed facility. He had removed the protective goggles while still in the game zone and a paintball hit his eye. On admission, he had periorbital hematoma, subconjunctival hemorrhage, corneal erosion and edema, a 4.5 mm hyphema with fibrin in the anterior chamber, 3 hour iridodialysis, and a subluxated lens with a white traumatic cataract [Figure 1A]. On ultrasound the retina was flat. Upon admission he was treated conservatively. However, 1 week later the IOP was elevated

Table 1. Summary of cases presented

Case no.	Age (years)	VA at admission	Final VA	Lens surgery	IOP elevation	Surgical procedures
1	22	HM	HM	+		Vitrectomy, lensectomy, silicone oil injection
2	19	HM	20/100	+	+	Anterior chamber washout, lensectomy+anchor+anterior vitrectomy+pupiloplasty+IOL sulcus implantation, iris fixation
3	30	HM	20/200	+	+	Cataract extraction+IOL implantation+anchor x 2+CTR+iris sutures, pupiloplasty
4	21	HM	FC 3 m			None
5	15	HM	20/30+	+	+	1. Corneal laceration repair, lensectomy, pupiloplasty 2. IOL implantation 3. Iridodialysis repair+pupilloplasty+IOL reposition 4. IOL sclera fixation, vitrectomy, trabeculectomy and EX-PRESS®implantation 5. Ahmed valve

VA = visual acuity, HM = hand movement, IOP = intraocular pressure, IOL = intraocular lens, CTR = circular tension ring, FC = finger count, FU = follow-up, m = months

Figure 1. Patient 2. [A] Intraoperative photograph at the beginning of surgery. Hyphema with fibrin, 5 hour iridodialysis and a subluxated lens with a white traumatic cataract. The surgery included anterior chamber washout, lensectomy and anterior vitrectomy. The malpositioned capsular bag was stabilized and secured to the scleral wall using a capsular anchor. The intraocular lens was placed in the sulcus and sutured to the iris and the torn iris was sutured to the sclera to re-form the iris diaphragm



[B] At late follow-up (6 months postoperatively). Intraocular lens stable with mid-fixed dilated pupil

to 40 mmHg, which was treated successfully with local antihypertensive agents. He then underwent anterior chamber washout and anterior vitrectomy. Prior to lens aspiration the malpositioned capsular bag was stabilized and secured to the scleral wall using a capsular anchor (AssiAnchor™, Hanita Lenses, Kibbutz Hanita, Israel). During lens removal it was evident that the posterior capsule was ruptured; the intraocular lens (IOL) was therefore placed in the sulcus and sutured to the iris to prevent IOL rotation. The detached and torn iris was sutured to the sclera to re-form the physiologic iris diaphragm [Figure 1B].

At the last follow-up, VA was 20/100, IOP 20 mmHg, the cornea was clear, the posterior chamber intraocular lens (PCIOL) was stable in the sulcus and sutured to the iris [Figure 1B]. Retinal pigment epithelium (RPE) changes were seen in the macula and the retina was flat. Optical coherence tomography (OCT) revealed atrophy of the fovea.

CASE 3

A 30 year old healthy male was hit in the right eye during a paintball game in June 2013. He had arrived at the game yard late and was not instructed properly on safety regulations and eye protection. While fixing the protective facemask in the play zone, he sustained a direct hit to the right eye. On arrival, VA was hand movement and IOP was 6 mmHg. Periorbital hematoma, subconjunctival hemorrhage, corneal erosion, severe diffuse corneal edema, hyphema with fibrin in the anterior chamber, iridodialysis of 2.5 hours, phacodonesis and subluxated lens were noted [Figure 2A]. The retina could not be visualized and was flat on ultrasound. Initially, he was treated conservatively with local antibiotics, steroids and cycloplegic agents. One week later, he developed high IOP (49 mmHg) and was treated successfully with local antihypertensive agents and systemic carbonic anhydrase inhibitors. Two weeks after the initial trauma he underwent removal of the traumatic cataract extraction and IOL implantation. The lens was subluxated and more than one-half of the zonules were ruptured. The intact capsule was repositioned and secured to the scleral wall using two intraocular anchoring devices (AssiAnchor) [Figure 2B] and a capsular tension ring (Hanita Lenses, Kibbutz Hanita Israel). The fixed dilated pupil was treated surgically by iris suturing (pupiloplasty). The retina was pale with peripheral hemorrhages and a choroidal rupture was seen.

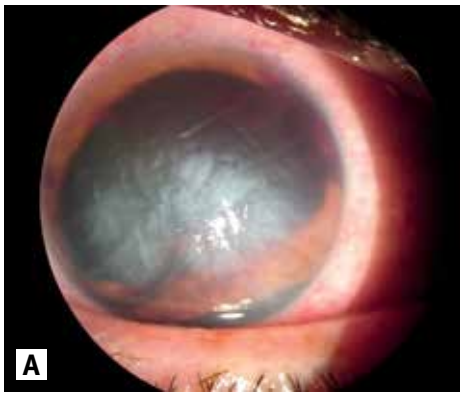
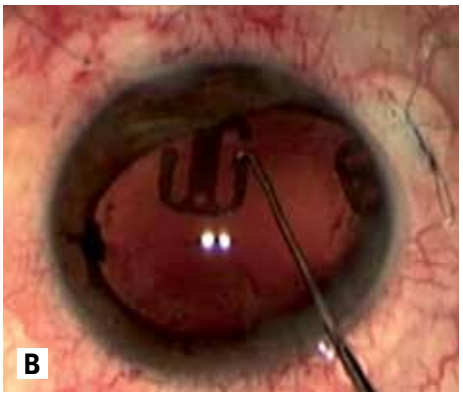
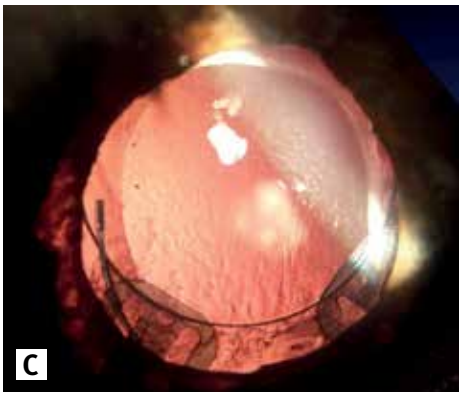


Figure 2. Patient 3 [A] At admission, severe, diffuse corneal edema, hyphema with fibrin in the anterior chamber, inferior iridodialysis of 3 hours, phacodonesis and subluxated lens



[B] At surgery. The patient underwent removal of the traumatic cataract and IOL implantation. The lens was subluxated and over one-half of the zonules were ruptured. The intact capsule was repositioned and secured to the scleral wall using two intraocular anchoring devices (AssiAnchor, Hanita Lenses, Kibbutz Hanita, Israel) and a capsular tension ring (Hanita Lenses, Kibbutz Hanita Israel). Implantation of the second intraocular anchoring device is seen here. The fixed, dilated pupil was treated surgically by pupilloplasty



[C] At late follow-up (3 months) the intraocular lens was stable. The two intraocular anchoring devices stabilize the lens capsule, maintaining a central position of the implanted IOL

At the last follow-up, 4 months after the injury, VA was 20/200, IOP 18 mmHg, the cornea was clear, the pupil was fixed and mid-dilated (6 mm), PCIOL was placed in the capsular bag, RPE changes were seen in the macula and the retina was flat. OCT revealed intraretinal fluid in the fovea [Figure 2A-C].

CASE 4

A 21 year old healthy male was hit in the left eye by a paintball during a game in August 2012. He was not wearing protective goggles. Initial examination revealed VA of hand movement, hematoma of lid and conjunctiva, hyphema, iridodialysis, traumatic mydriasis, vitreous hemorrhage, and flat retina on ultrasound. He was treated conservatively. A few days later the vitreous hemorrhage was partially cleared, but VA remained limited to finger count at 1 meter. On fundus examination, pre- and subretinal hemorrhages infranasal to the disk and macular hemorrhage were seen.

At the last follow-up, one year after the injury, VA was finger count at 3 m with iridodialysis, mydriasis, and clear lens. Fundus examination revealed a nasal chorioretinal scar and pigmentary changes in the macula.

CASE 5

A healthy 15 year old male was hit in the right eye immediately after removing his protective facemask at the end of a paintball game while still in the game area, in August 2013. On arrival at the emergency room, VA was hand movement, and corneal laceration, iridodialysis, traumatic cataract and subluxated lens were evident.

An urgent initial operation comprising corneal laceration repair and lensectomy was performed. He developed high IOP and was treated successfully with local antihypertensive drops. A second operation was performed 5 months later and included release of iris adhesions and IOL implantation to the sulcus. Mild intraretinal bleeding was seen. A third operation 1 month later included resuturing of the iris dialysis, pupilloplasty and IOL repositioning with iris sutures.

A few weeks later, the IOP was 25 mmHg under maximal topical treatment and was again decentrated. He underwent a fourth operation, which included repositioning of PCIOL by scleral fixation, anterior vitrectomy and a filter operation using the EX-PRESS® Glaucoma Filtration Device P50 (Alcon Laboratories, Fort Worth, TX, USA).

Following this operation, IOP was initially controlled; however, high pressure recurred after 10 days and bleb needling was performed. Two days after the surgery, the IOP was low (3 mmHg) and multiple retinal hemorrhages were seen, probably secondary to postoperative hypotension. Fluorescein angiography did not reveal any filling defects. High pressure > 40 mmHg, non-responsive to local and systemic therapy, recurred and an Ahmed shunt was implanted. At last examination, IOP was 11 mmHg, the cornea was clear, the IOL was stable and well-centered, most retinal hemorrhages had disappeared, and visual acuity regained 20/30+ acuity.

Table 2. Review of papers published on Paintball ocular injuries

Author [ref]	No. of cases	Males (%)	Average age (yrs)	No of surgeries (%)	Final VA ≤ 20/200 (%)	Anterior segment injury (%)	Posterior segment injury (%)	Elevated IOP	Lens surgery (%)
Kruger & Acton [17]	6	100	13–26 (18.8)	50	50	16.7	66.7	33	16.7
Kitchens & Danis [18]	11		9–41 (22)	36.3	63.7	63.7	63.7		36.4
Pahk & Adelman [12]	14	93	9–30 (17)	71	43	71	50	14	28
Alliman et al. [4]	36		3–64 (21)	81%	50	81	22	8	11
Taban & Sears [20]	8		11–26 (16)	87.5	50	62.5	44	25	62.5
Greven & Bashinsky [5]	19	95	8–26 (16)	47.4	36		8	42	37
Baath et al. [21]	3	100	13–18 (16)	33.3	67				
Fineman et al. [7]	35	100	13–51 (22)		46	60	62.9	11.4	22.9
Current study	5	100	15–30 (21.4)	80	60	60	100	60	80

DISCUSSION

Despite the decrease in ocular injuries during commercial war games, the proliferation of paintball guns has led to a proportional increase in the number of ocular eye injuries caused by paintballs during unsupervised, non-commercial war games [8]. In the present study, most cases occurred in licensed facilities, but safety regulations were not properly instructed or reinforced. All cases occurred, as expected, in young (15–30 year old) males. In the United States, paintball-related eye injuries treated in emergency rooms has more than doubled, from 545 in 1998 to over 1200 in 2000, with nearly 40% of those cases occurring in pediatric patients [9].

The small size, relatively high mass (3.5 g) and, most important, the high velocity of paintballs fired from CO_2-powered guns, explain their ability to cause severe ocular injuries [7]. The earliest study of war game injuries is from 1985 [10], when Easterbrook and Pashby reported 26 cases of ocular paintball injuries in a 1 year period despite the availability of eye guards. Since then, several reports of ocular trauma due to paintballs have been published [3,7,11,12]. Despite numerous surgical interventions, many eyes remain severely compromised. Surgical intervention was required in 50–81% of cases [3,4,11]. Better visual acuity at presentation was correlated with better final visual acuity, possibly indicating that the nature and severity of the original injury (rather than management) plays the most significant prognostic role. Similarly, in the present study, final visual function was related to the initial retinal damage. The number of operations was not an indicator of the severity of ocular injury or final outcome. In fact, the patient who did not require surgery (patient # 4) ended up with a poor visual outcome (finger count), whereas in the patient who had undergone five operations (patient # 5) the visual acuity was excellent (20/30+) [13]. A review of papers published on paintball ocular injuries is shown in Table 2.

MECHANISM OF INJURY

The mechanism of ocular injury caused by paintballs is typical of severe, blunt ocular trauma [1]. It may cause serious anterior chamber, posterior chamber, lens, glaucoma and retinal damage, frequently resulting in permanent visual loss. Coup and countercoup effects and anterior-posterior compression with equatorial expansion result in ocular tissue damage [14]. Large objects that cause diffuse periorbital impact usually result in mild ocular damage because the force is absorbed by the orbital margin. A localized impact usually results in significantly more serious ocular damage, especially with small, high speed objects [15]. Since the size of the paintball sphere is a little smaller than the orbital socket, the entire energy is absorbed by the eye globe and the orbital rim is typically unharmed. Paintballs are designed to rupture on impact, there is no exit wound and all the energy is released at the site of impact. Therefore, tissue damage is proportional to the product of projectile mass and the square of the impact velocity [1].

In the current series, three of the five patients suffered significant, long-term, high IOP, probably a result of damage to the trabecular meshwork. Four patients sustained significant lens damage, requiring extraction and IOL implantation. Since the damage was caused by blunt trauma with significant compression of the globe, most cases resulted in damage to the zonules with subluxation of the lens and lens capsule tears. In one case (# 5), the IOL was secured by the iris and later, scleral fixation. Two other cases (# 2 and 3) were treated by lens capsule conservation using a capsular anchor. This method has not been described previously in such cases [16]. The capsular anchoring device (AssiAnchor, Hanita Lenses) is a 2.5 mm wide PMMA (polymethyl methacrylate) uniplanar implant and can therefore be inserted through a regular corneal incision. The two lateral arms of the device are inserted through the capsulorrhexis and positioned behind the anterior lens capsule, while the central element is placed

in front of the anterior capsule. Thus, it creates a clip that adheres to a small segment of the anterior capsule. The tips of the lateral arms are designed to reach the lens equator and provide segmental equatorial support. The anterior rod is sutured to the scleral wall using a non-absorbable suture [17].

Paintball industry standards for eye protection have been developed and should be implemented for all participants [1]. It is tragic that all these injuries could have been prevented with protective eyewear had safety regulations been reinforced [10]. Scrupulous use of protective eyewear might have eliminated 97% of injuries and must be constantly emphasized to paintball players [4,17,18]. Previous reports have observed that only a minority of injuries occur during formal games [5,7] and most of those patients were not wearing eye protection. The extreme physical nature of this game frequently causes fogging of the protective mask. The major identifiable reason for removal of an eye protective device reported in some series was fogging [19] or paint splattering that obscured the central viewing zone [1,7]. It should be strongly emphasized that under no circumstances should the protective mask be removed in the game zone or before total cessation of the game. Consistent use of face guards or safety glasses, coupled with a clear knowledge of the potential consequences might seem easily attainable, but the ongoing accumulation of experience with paintball injuries attests otherwise [4,21].

CONCLUSIONS

Given the growing popularity of paintball, there appears to be a commensurate increase in eye injuries related to the game, most of which are easily preventable. Despite efforts to increase public awareness and improve safety features, the incidence of eye injuries has increased over time. We believe that prevention should be targeted toward improving safety regulations and strict enforcement during the game, along with continuing education regarding the use of face and eye protection.

Recommendations that would help to decrease ocular injuries include the wearing of designated protective polycarbonate goggles at all times, no shooting at the head or at close range, and a ban on alcohol and drug use before the game. Participants in paintball war games need to remember that an injury that would be trivial elsewhere in the body might be serious and irreversible when it involves the eye.

Conflicts of Interest
E.I. Assia is a consultant at Hanita Lenses and the inventor of the capsular anchor (AssiaAnchor) used in two of the cases.

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"The most perfect technique is that which is not noticed at all"

Pablo Casals (1876-1973), Spanish cellist, conductor and composer, considered the greatest cellist of all time

"Remember, we all stumble, every one of us. That's why it's a comfort to go hand in hand"

Emily Kimbrough (1899-1989), American author and journalist