Characteristics of Pellet Injuries to the Orbit

A. Şahap Kükner a  Turgut Yilmaz b  Serdal Çelebi a  Şafak Karslioğlu c  Gürsoy Alagöz a  Didem Serin a  M. Akif Acar d  M. Faik Özveren e

a  Department of Ophthalmology, Izzet Baysal Medical Faculty, Golkoy, Turkey  b  Private Practice, Elazığ, Turkey  c  Şişli Etfal Research and Training Hospital, Istanbul, Turkey  d  Department of Ophthalmology, Ankara Research and Training Hospital, and  e  Department of Neurosurgery, Ankara Numune Research and Training Hospital, Ankara, Turkey

Key Words
Injury, orbital  •  Injury, pellet  •  Optic nerve trauma

Abstract
Purpose: To investigate the features of orbital injuries by pellets fired from the front. Design: Retrospective, 4 cases of pellet injuries. Methods: Five orbits of 4 patients who sustained pellet injuries received from the front were reviewed retrospectively. The course of injury and results were assessed. Radiological examinations were reviewed. The patients were evaluated between December 1996 and June 2004. Results: Five orbits of 4 patients sustained injuries caused by pellets fired from an anterior direction. The globe in the injured orbit was intact in 2 cases. Severe loss of vision was also present in these 2 globes due to optic nerve involvement. Final visual acuity was down to no light perception in 4 eyes and limited to light perception in 1 eye. Conclusions: The prognosis of orbital pellet injuries is, unfortunately, poor. A pellet passing through the floor of the orbit often causes double perforation of the globe and, once in the orbital aperture, it travels towards the apex as a result of the conical shape of the orbit and lodges in the optic canal or its entrance, severely damaging the optic nerve. Surgery or other treatments are usually unsuccessful. Even if the globe is intact, vision is usually severely impaired.

Introduction
Orbital and ocular injuries by pellets fired from an anterior direction usually result in double perforation of the globe and severe injury to the optic nerve. This type of injury generally occurs while hunting, playing with an air gun or in criminal cases. The globe fills a great proportion of the orbital entrance. Therefore, it cannot escape a pellet and sustains a double perforation, which is a serious injury. Furthermore, the pellet travels posteriorly towards the orbital apex, either lodges at the apex or, more frequently, in the optic canal where the optic nerve passes through. In both cases, severe damage of the optic nerve ensues. Unfortunately, there is no effective treatment of such injuries and visual acuity is generally severely impaired. Even if the pellet passes between the globe and the orbital rim without any direct contact with the globe, severe loss of vision still occurs due to optic nerve damage.

Numerous studies highlighted the poor prognosis of pellet injuries to the orbit, globe and optic nerve, and recommended restrictions on the trade and use of pellet guns and rifles [1–3].

This study evaluated 5 orbits of 4 patients with pellet injuries clinically and radiologically. The globe was intact in 2 of these patients, whereas 3 globes of the remaining 2 patients were severely injured. There was severe vision loss in all 5 cases.
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Methods

Clinical charts of 4 patients wounded by a pellet between December 1996 and May 2003 and presented between December 1996 and June 2004 were reviewed retrospectively. Systemic, neurological and ophthalmic examinations as well as radiological investigations were performed and the results were reviewed. Patients 1 and 4 presented to the Firat University Faculty of Medicine, patient 2 presented to the Ministry of Health Ankara Training Hospital and Izzet Baysal Faculty of Medicine, and patient 3 presented to the Ophthalmology Clinic of the Şişli Etfal Hospital.

We also declare at this point that we have adhered to the Declaration of Helsinki and all federal or state laws in our country.

Results

Patient 1 was a 22-year-old male who was shot from a distance with a pellet gun while hunting. Systemic and neurological examinations were unremarkable.

On ophthalmic examination, the right eye was intact, with full visual acuity; there was subconjunctival hemorrhage of the left eye with a 3-mm perforation of the temporal sclera close to the limbus, and the eyelid was edematous. The anterior chamber was filled with hyphema, preventing visualization of the posterior segment. Visual acuity was limited to hand motion and the afferent pupillary defect was present in the right eye. Since the pupil could not be visualized as a result of total hyphema of the left eye, the afferent pupillary defect was examined indirectly by shining light to the injured left eye and then to the right eye. Once miosis was observed, light was shone to the left eye again and dilation of the right pupil was observed.

CT images revealed that the posterior sclera was obscure, the retrobulbar area was filled with a dense matter (blood) and a metallic foreign body was localized within the optic canal (fig. 1). Ophthalmic ultrasound showed posterior vitreous detachment and subhyaloid and preretinal hemorrhage in the posterior segment (fig. 2).

The patient was given tetanus prophylaxis and put on wide-spectrum antibiotic treatment. The patient was operated on day 1 and the perforation of the sclera was sutured. The hyphema disappeared on day 10 and the lens was found to be opaque. The patient was operated again on day 15 and the cataract was removed by phacoemulsification, the vitreous hemorrhage was evacuated by pars plana vitrectomy. The retina was attached. The posterior exit wound was observed 2 disk diameters temporal to the fovea and endolaser photocoagulation was performed around the perforation. The macula was slightly edematous. The operation was terminated after silicone injection. The retina was attached and the patient was able to count fingers at 15 cm 1 day after the operation, but the afferent pupillary defect persisted despite a silent eye. Se-
vere proliferative vitreoretinopathy developed 1 month after the operation, progressed towards total retinal detachment and resulted in phthisis despite silicone injection. The final visual acuity was light perception.

Patient 2, a 36-year-old male, was neurologically well and in good general health. He was shot 1 day before presentation with a pellet gun from a close distance. Ophthalmic examination revealed no visual acuity in either eye (no light perception).

There were multiple pellet wounds on his face, forehead and head. On ophthalmic examination, there was subconjunctival hemorrhage and edema, hematoma and multiple pellet wounds on both eyelids. There was a perforation of the sclera of the right eye, temporal to the limbus, and corneal edema. The anterior chamber was filled with hyphema which prevented visualization of the posterior segment. In the left eye, there were 2 perforations, one above the limbus and the other at the center of the cornea. The iris and pupil were irregular, the lens capsule was perforated and the lens was opaque. Direct and indirect pupillary reactions were absent in both eyes and both eyes were hypotonic. Wide-spectrum antibiotic treatment was initiated due to the presentation of bilateral double perforation, and tetanus prophylaxis was given.

The patient was operated and the anterior perforations in both eyes were sutured.

A direct radiograph depicted multiple pellets scattered in the head region. Pellets outside the orbit were randomly scattered, while those in the orbit were concentrated in a region corresponding to the apex. Pellets in the forehead were squashed and flattened, whereas pellets in the orbit retained their shapes (fig. 3). CT showed that almost all of the pellets in the orbital region traveled posteriorly towards the apex, with most of them lodged in the optic canal. It was clearly visible that these pellets were not fragmented or flattened but retained their spherical shapes (fig. 4).

On the 15th day of follow-up, bilateral phthisis and loosening of the sutures were noted. One month after the operation, there was no light perception in either eye. The intraocular pressure was 2 mm Hg in the right eye and 0 in the left eye. The right cornea was transparent, there was no light perception in either eye. The corneal diameter was small, the anterior chamber shallow, the iris bulgy and the lens swollen and opaque. Phthisis developed in both eyes after 5 months.

Patient 3 was shot by a pellet rifle 1 year before presentation and the pellets entered the orbit beneath the right eyebrow. Physical examination 1 year after the injury revealed a scar by the entry wound close to the eyebrow, total ptosis of the right eyelid with an interpupillary fissure height of 0 mm and a levator function of 6 mm, lateral deviation, a limited upper gaze, a natural anterior segment, scarring of the macula, and optic nerve atrophy.

There was no light perception, the right pupil was fixed and dilated, with no reaction to light. Therefore, we checked the afferent pupillary defect indirectly. Light was shone into the right, i.e. the injured eye, and then to the left eye. When miosis was observed, light was shone to the right eye again and the left pupil dilated. The examination of the left eye was unremarkable and visual acuity was full. The patient had not been treated for intracranial and intraorbital pellets.

CT images obtained on the day of injury showed 2 metallic foreign bodies, one at the orbital apex by the opening of the optic canal and the other within the frontal lobe (fig. 5), and there was marked exophthalmos. The patient did not consent to the ptosis and strabismus surgeries recommended as cosmetic treatments, and was lost to follow-up.

Patient 4 was a 61-year-old male shot in the right eye by a pellet rifle 5 h before presentation. General and neurological examinations were normal. Ophthalmic exam-
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A summary of all patient data is to be found in table 1.

Discussion

There are various causes of orbit and eye injuries and the prognosis varies considerably. The prognosis of orbital injuries caused by a pellet shot from the front is generally poor. Five orbits of 4 patients were injured and the optic nerves severely damaged, with consequent loss of vision in all cases. There were double perforations of 3 eyes, while the integrity of the remaining 2 eyes was not compromised.

When patient 1 first presented, his visual acuity was limited to hand motion. His cataract was removed on day 15, when the hyphema was resolved. In the same session, the intravitreous hemorrhage was drained, laser photocoagulation was applied around the posterior retinal tear and silicone was injected intravitreally. Following the operation, although the retina was attached and the eye looked normal, the corrected visual acuity was limited to counting fingers at 15 cm and there was an afferent pupillary defect.

When patient 2 presented, he had double perforations of both eyes with absolute vision loss. Both eyes became phthisical.

Patient 3 presented to us 1 year after the accident. The sclera was intact, the macula scarred, the optic nerve atrophied, visual acuity was down to no light perception and there was an afferent pupillary defect.
Patient 4 did not have any light perception and had an afferent pupillary defect despite an intact eye and an only mild edema of the retina by the posterior pole. Optic nerve decompression was performed, but visual acuity did not improve. Especially in patients 3 and 4, the primary cause of vision loss was optic nerve damage.

Surgery does not affect the outcome considerably when the pellet is lodged in the optic canal. If the injury is unilateral, the prognosis can be predicted by observing the afferent pupillary defect. The prognosis is usually poor in the presence of an afferent pupillary defect even if the globe is intact. The prognosis can also be predicted by observing the afferent pupillary defect even if the injury is bilateral, as was the case with patient 2.

CT is the best imaging modality to depict metallic pellets. It is indicated in patients, especially children, when a foreign body is suspected and patients cannot provide a reliable history [4]. If the foreign body contains wood splinters, it may not show up on CT images, in which case MRI should be preferred [5, 6].

Fulcher et al. [4] reviewed 40 patients with an orbital foreign object and developed a protocol. Based on this protocol, CT should be obtained and MRI should be requested when nonmetallic foreign objects are suspected. Tetanus prophylaxis should be given and wide-spectrum antimicrobial treatment should be initiated. The foreign body should be surgically removed if it is organic and also if it is inorganic in case it has resulted in complications. Anteriorly located foreign bodies should be discussed with the patient and can be removed or left in situ unless complicated. Posteriorly located, uncomplicated inorganic foreign bodies should be left in situ [4]. We generally adhered to this protocol with our patients. There were double perforations in 3 of the 5 injuries and, to make matters worse, 1 or more pellets were lodged within the optic canal, causing severe damage to the optic nerve. The main reason why the severe vision loss was unresponsive to treatment was the optic nerve damage.

We observed some features that were common among these cases. There was double perforation in 3 of the 5 injuries and, to make matters worse, 1 or more pellets were lodged within the optic canal, causing severe damage to the optic nerve. The main reason why the severe vision loss was unresponsive to treatment was the optic nerve damage.

### Table 1. Patient data

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (years)</th>
<th>Gender</th>
<th>Time and cause of injury</th>
<th>Type of injury</th>
<th>Location of pellet(s)</th>
<th>Visual acuity</th>
<th>Treatment</th>
<th>Final status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22</td>
<td>M</td>
<td>2 days before presentation while hunting</td>
<td>double perforation of the left eye</td>
<td>1 Pellet in the left optic canal</td>
<td>P (+) perforation repair, lens extraction, PPV</td>
<td>phthisis</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>36</td>
<td>M</td>
<td>1 day before presentation</td>
<td>double perforation of both eyes</td>
<td>multiple pellets at bilateral retinas and optic canals</td>
<td>P (+) perforation repair bilateral phthisis</td>
<td>phthisis</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>M</td>
<td>1 year before presentation, assault</td>
<td>double perforation of both eyes</td>
<td>1 pellet at the right orbital apex, bilateral absence of pupillary reflex</td>
<td>P (+) no patient consent to treatment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>61</td>
<td>M</td>
<td>5 h before presentation, accident</td>
<td>double perforation of both eyes</td>
<td>1 pellet in the right optic canal</td>
<td>P (-) optic nerve decompression</td>
<td></td>
<td>optic atrophy</td>
</tr>
</tbody>
</table>

APD = Afferent pupillary defect; PPV = pars plana vitrectomy; P = perception.
When we evaluated the dispersion of the pellets on CT images and direct radiographs, we noticed that the pellets were dispersed randomly outside the orbit — whereas, once in the orbit, they were lodged at the apex and particularly in the optic canal. The anatomy of the orbit resembles a cone. The optic canal lies in the apex of this cone. When a projectile enters the orbit, it passes through the soft tissues of the orbit which slow down the projectile. If the projectile hits the orbital walls at an acute angle, it deflects posteriorly and, as the orbit has the shape of a funnel, is directed towards the optic canal. If the pellet is solitary, it generally lodges in the optic canal, as was the case with patients 1 and 4. If there are multiple pellets, as in patient 2, some of them pass into the optic canal, while others cluster at the apex in front of the optic canal.

Another feature we noticed was the fact that pellets in the forehead region were flattened and sometimes fragmented, whereas those in the orbit retained their shapes. Pellets hitting the forehead hit the bone at a greater velocity, since there is not sufficient subcutaneous tissue to slow them down, and usually at a right or near-right angle. As a result, pellets lose their shape and become flattened. On the other hand, pellets that enter the orbit slow down while passing through soft tissues and even if they hit the orbital wall, they hit at an acute angle and deflect, retaining their spherical shape.

Double perforations of the globe are usually observed in pellet injuries to the orbit and they are usually accompanied by intraocular hemorrhage and retinal detachment. Even if the pellet is rarely able to pass between the orbital rim and the globe, as observed in patients 3 and 4, it still follows this path without injuring the globe, travels posteriorly and lodges by the apex or in the optic canal, causing severe vision loss by optic nerve damage.

Traumatic optic neuropathies are classified as direct or indirect. The prognosis is poor in direct traumatic optic neuropathy and a pellet injury is one of the worst examples of this type of neuropathy. The optic nerve not only sustains a direct injury at the moment of impact but also an indirect injury by optic nerve ischemia as a result of the mechanical pressure and consequent disruption of the circulation when the pellet is lodged in the optic canal. Optic atrophy can be observed within a month.

Both high-dose steroids [7] have been given and optic nerve sheath decompression has been performed as a treatment for traumatic optic neuropathy. There are various complications of surgical interventions in connection with optic nerve decompression, and visual acuity can worsen after decompression [8]. However, patient 4 did not have any light perception, and the optic nerve decompression was performed by neurosurgeons.

Radiography, ultrasound and especially CT should be preferred for imaging in orbital injuries. MRI can be hazardous since it can cause a metallic object to move [9].

Considering that the prognosis of pellet injuries to the orbit is poor, attention should be drawn to prevention. Even though there were no children among our patients, the sale of air guns and pellet guns as toys and the use of pellet rifles for sporting purposes should be restricted. Strict control should be implemented on the sale of pellet rifles and guns.

References