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The usefulness of computed tomography with the reduction of metal artifacts in the location of an intraorbital foreign body — a case report

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Abstract: Intraorbital foreign bodies still remain an unsolved and serious diagnostic problem. Due to the complicated anatomical orbital structure, both the diagnosis and treatment of these injuries are considered to be one of the most challenging. We present a case of a metallic foreign body (a bullet) imbeded in the orbit of a 10-year-old boy. Only after performing computed tomography imaging using the metal artifacts reduction algorithm it was possible to properly localize the foreign body. The issue of intraorbital foreign bodies is interdisciplinary and requires the co-operation between many specialists, including ophthalmologists, otorhinolaryngologists and radiologists.

Keywords: foreign body, computed tomography, eye orbit.

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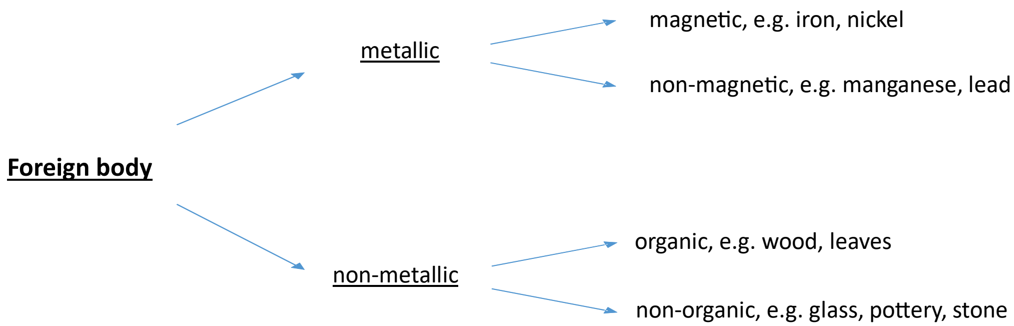
Introduction

Penetrating orbital injuries which are most often related to the high speed with which such an injury is inflicted, e.g. in consequence of a shot or a traffic accident, constitute an interdisciplinary problem. Patients with foreign bodies embedded in the orbit (intraorbital injuries) should be consulted by a neurosurgeon, surgeon, maxillofacial surgeon, pathologist, ophthalmologist or laryngologist to name a few. This group of patients poses an exceptionally difficult problem, both from the diagnostic and therapeutic point of view, since the risk of damaging the organ of vision appears at the moment of the injury, as well as during the attempts at treating the said injury, regardless of the possible development of infectious, allergic, edematous or hemorrhaging complications. The term "intraorbital injury" refers to the situation when a foreign body is situated inside the orbit but outside the eyeball. Such injuries are more common in males than in females and more frequently affect younger as opposed to older patients. The most classic and at the same time the most valid division of intraorbital foreign bodies is based on their character (Graph 1). In general, metal and glass objects are associated with a good tolerance; if the patient does not demonstrate any symptoms or ailments, he or she may be kept under observation [1–3]. Unfortunately, in case of a biological material with its abundant bacterial flora, immunological intolerance of this particular foreign body and the resultant tendency to inflammatory state development, even a short-time exposure may exert a destructive effect both on the optic nerve and the structures of the central nervous system [4–11]. The occurrence and spreading of the complications is fostered among others by the location of the orbit (the boundary between the facial and cerebral parts of the cranium) or the orbital anatomical construction (thin bone walls, the blood vessel network). In the course of the therapy, the first step should consist in as precise as possible location of the foreign body using radiologic imaging methods (X-ray, USG, CT, MRI) that would be fitted to its chemical origin [12–14]. Than, taking into consideration the reccommendations (Table 1) and location of the object, the method of treatment that individually matches the findings in a given patient can be selected.



Graph 1.

Table 1. Indications for surgical treatment of patients with intraorbital foreign bodies according to Al-Mujaini *et al.*, 2007 + modifications added by the present authors.

— a large or pointed foreign body
— symptoms of inflammatory state development
— exophtalmia
— limited mobility
— conjunctival edema
— a detectable mass within the orbit
— pressure on the optic nerve (limited vision, blindness)
— an abscess visualized in an imaging test
— image enhancement in an imaging test
— suspected organic or copper elements
— formation of a fistula (cutaneous, nasal or into the cranial fossa)

Objective

The objective of the paper is the presentation of clinical observations addressing the diagnostic and therapeutic management methods in the case of an orbital injury complicated by the presence of a metallic foreign body.

Material and Methods

The patient (MK), aged 10 years, was accidentally shot in the area of the right eyeball (Figures 1–18, Tables 1–3) by his brother with an air gun belonging to their father (Fig. 1, Table 2) on August 6, 2017 (Fig. 8). In the course of the initial examination, the child was somnolent and nauseous. Prior to the accident, he did not suffer from any serious diseases. He was consulted by an ophthalmologist on August 6, 2017 (Table 3). The boy presented with symmetrically placed eyeballs, no exophtalmia, with limited mobility of the eyeball to the right and upwards and diplopia when looking in the said directions. The entry wound was healing by primary adhesion.

In order to determine the location of the foreign body in the right orbit, the diagnostic management began from the skull X-ray (Fig. 3–4). In spite of the primary determination of the placement of the fragments of the bullet and their appropriate visualization with respect to the bone structures, a decision was made to extend the imaging testing to include USG of the orbits (Fig. 6), where the echogram of the right eyeball was described as normal. In the lower part of the orbit, two irregular shadows were seen conically; they might have represented foreign bodies. Unfortunately, the low diagnostic value necessitated the testing to be continued. A decision was made to use CT imaging aiming at defining the location and relation of the foreign bodies to the surrounding soft tissue (Fig. 5–6). The test was performed using a spiral multislice CT scanner with the following characteristics: number of slices — 64, thickness and space between slices — 0.63 mm, lamp voltage — 120 kV, lamp power — 300 mA, rotation time — 1 sec., CTDIvol dose — 63.33 mGy, soft tissue and bone kernel reconstruction windowing. Unfortunately, due to the character of the penetrating foreign body and numerous artifacts, the test turned out to be insufficient both in determining the bullet trajectory and in defining the precise location of the foreign bodies with respect to the orbital wall and content.

On August 6, 2017 the patient was subjected to a repeated ophthalmological consultation which revealed (Table 3) preserved mobility of both eyeballs, an entry wound below the lower eyelid within the cheek, swelling and minor bruising. On the same day, a neurosurgical examination did not demonstrate any meningeal signs or focal damage to the central nervous system. It was decided to transfer the patient for further treatment to the Maxillo-facial Surgery Ward of the Ludwik Rydygier Hospital in Krakow (Table 3). The patient was operated on in the said ward on August 7, 2017 using the palpebrofrontal section (Fig. 7). The right orbit was explored. Using the above mentioned surgical section the surgeons failed to identify and by the same token to remove the bullet. After the procedure, general antibiotic therapy was introduced and orthognatic exercises were recommended. No complications were noted in the periprocedural period.

A decision was made to subject the patient to a repeated ophthalmological consultation (Table 3) which indicated mechanical blepharoptosis, swelling of the frontal part of the right eye, ecchymoses of the eyelids and persistent limitation of the right eyeball mobility with double vision directed to the right and upper side. The linear postoperative wound was protected by interrupted sutures and was properly healing. Below the outer corner of the eye there was an entry wound secured by an interrupted suture (Fig. 8–10).

In view of the course of the current treatment a decision was made to extend the imaging test diagnostic management to include CT testing of the orbital cavities using the algorithm of reduction of metal artifacts (Fig. 12–14). The computed tomography test was performed using a spiral multislice CT scanner with the following characteristics: number of slices — 80, thickness and space between slices — 1 mm, lamp voltage — 120 kV, lamp power — 157–210 mA, rotation time — 0.51 sec., CTDIvol dose — 63.33 mGy, soft tissue and bone kernel reconstruction windowing, the manufacturer's algorhitm SEMAR (Single Energy Metal Artefact Reduction).

Further therapy was decided to be implemented in the Department/Ward of Ophthalmology and Ophtalmological Oncology of the University Hospital of Krakow. On October 9, 2017, a team consisting of laryngologists and ophtalmologists performed the surgery. The right orbit was incised from the lateral approach — the Kroenlain orbitothomy — the incision extending from the right supercillary arch to the zygomatic process of the maxilla. The zygomatic process was partially excised to allow for accessing the top of the orbital cone (Fig. 15). The tissues situated at the lower part of the incision were dissected in keeping with the CT image of the orbit (Fig. 12–14), a fragment of the bullet formed as a completely flat plate was identified and removed (Fig. 16). The orbital periosteum was dissected free and thus the orbital cone was reached, the periosteum was dissected at the level of the lateral rectus muscle, the soft tissues were penetrated and no foreign body was detected. Subsequently, in keeping with the CT image, the slightly altered and congested superior rectus was dissected and another flat metallic foreign body embedded among the muscle fibers was identified and removed (Fig. 16). The postoperative mobility of the oculomotor muscles was preserved and complete hemostasis was achieved.

Results

No complications were noted in the course of the procedure. Two metallic foreign bodies (buckshot) were removed from the right orbit. During hospitalization the boy received general antibiotic therapy and decongestants. The patient was ordered to perform exercises consisting in moving the eyeballs within the range of motion of the operated on oculomotor muscles. The healing process was normal. A consultation with an ophthalmologist after the second procedure was recommended (Table 3).

The removed material was referred for scanning microscope examination to the Chair/Department of Otolaryngology of the University Hospital of Krakow in order to determine its effect on the surrounding tissues and growth properties of pathological microbes (Fig. 17–18).

Table 2. Chemical analysis of the bullet "Proma" S.C. Sample description: the analysis performed on August 10, 2017 Statistical data on the examined block.

Moderate	Au % 0.00	Ag % 0.008	Pt % 0.000	Pd % —	Cu % 0.480	Zn % 0.033	Sn % 0.010	Pb % 99.0
Moderate	Fe % 0.121	Cr % 0.033	Ni % —	Mo % 0.009	Co % 0.016	Rh % 0.034	Ru % 0.010	In % —
Moderate	Ir % 0.121	W % —	Bi % —	Mn % —	Ga % —	Cd % —		

Table 3. Ophtalmological consultation.

	August 6, 2017 Immediately after trauma	August 6, 2017 Before the first procedure	August 8, 2017 After the first procedure	August 10, 2017 Before the second procedure	August 10, 2017 After the second procedure
Vis RE	1.0 s.cor	1.0 s.cor	1.0 s.cor	1.0 s.cor	1.0 s.cor
Vis LE	1.0 s.cor	0.8 s.cor	1.0 s.cor	1.0 s.cor	1.0 s.cor
Sn RE	0.5 s.cor	0.5 s.cor	0.5 s.cor	0.5 s.cor	0.5 s.cor
Sn LE	0.5 s.cor	0.5 s.cor	0.5 s.cor	0.5 s.cor	0.5 s.cor
Tp RE	—	—	—	11 mmHg	13 mmHg
Tp LE	—	—	—	11 mmHg	14 mmHg

Fischerscope® XRAY XAN 215; High voltage = 50 kV (875); Preliminary filter = AI1000; Collimator 1 = 1.00; Dm. Anode current 900 uA; Measurement distance = –).51 mm; Product: 6 / Gold Global Dir.: Gold; Application: 5 / Gold Global; Number of measurements 1; Duration of measurement 30 s

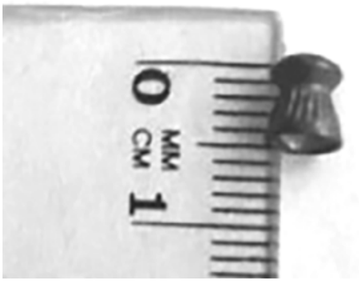


Fig. 1. The bullet — from the original wrapping.

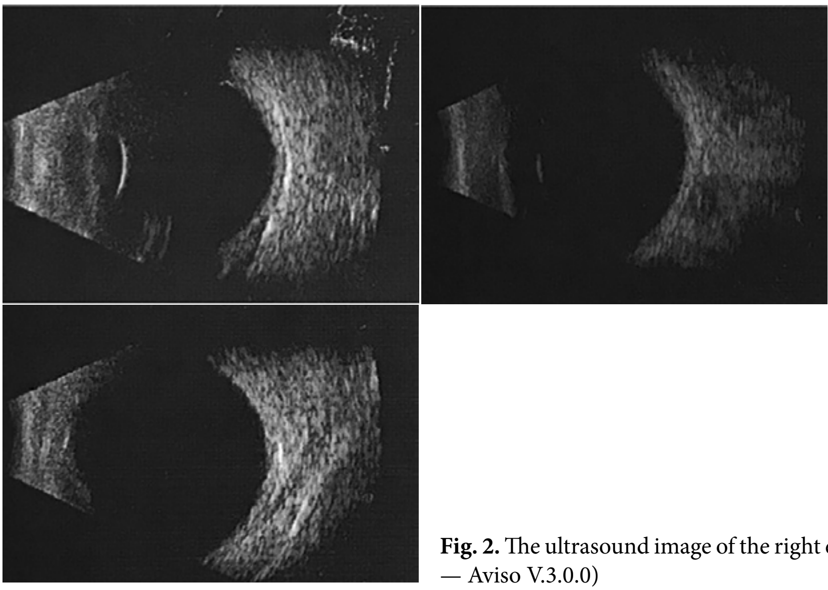


Fig. 2. The ultrasound image of the right eye (Quantel Medical — Aviso V.3.0.0)

Fig. 3. Skull X-ray examination, PA projection — foreign bodies within the orbit.

Fig. 4. Skull X-ray examination, lateral projection — foreign bodies within the orbit.

Fig. 5. CT imaging — a transverse image, intensified metal artefacts impeding the evaluation of the foreign body.

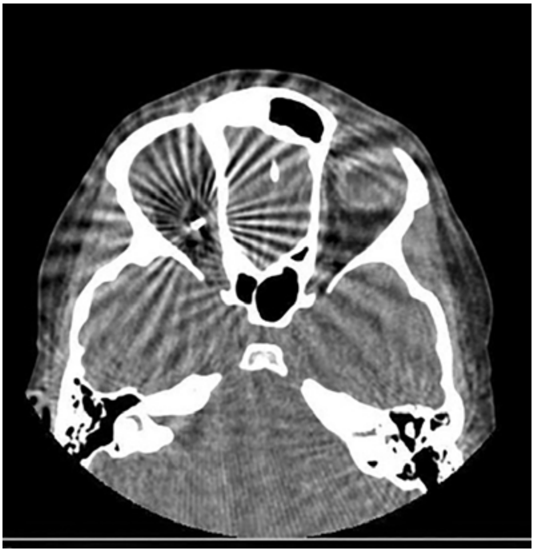


Fig. 6. CT imaging — a transverse image, intensified metal artefacts impeding the evaluation of the foreign body.

Fig. 7. A photograph taken after the procedure performed using the supra-palpebral approach.

Fig. 8. A photograph taken after the first failed surgical procedure showing the healing postoperative wound and the gunshot wound.

Fig. 9. A photograph of the healing wound following the removal of stiches — note the remnants of a subconjunctival hemorrhage.

Fig. 10. A photograph taken after complete healing of the first surgery wound with foreign bodies continuing to remain within the orbit.

Fig. 11. A photograph taken after the second procedure performed from the lateral approach following the successful removal of both fragments of the bullet.

Fig. 12. CT imaging — frontal reconstruction, obtained using the algorithm reducing metal artifacts and thus facilitating the assessment of foreign bodies.

Fig. 13. CT imaging — a transverse image, obtained using the algorhithm reducing metal artifacts and thus facilitating the assessment of foreign bodies.

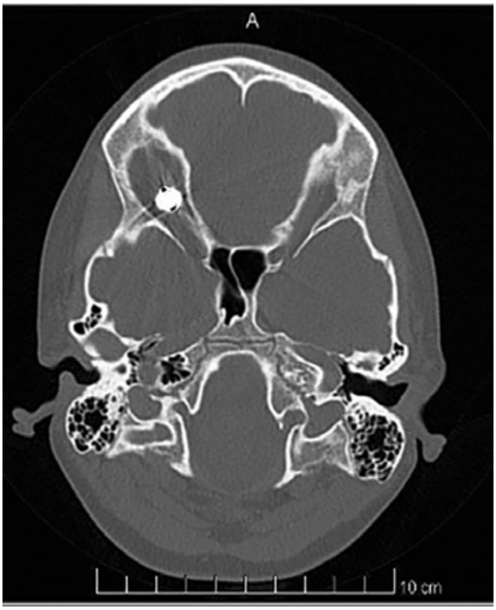


Fig. 14. CT imaging — a transverse image, obtained using the algorhithm reducing metal artifacts and thus facilitating the assessment of foreign bodies.

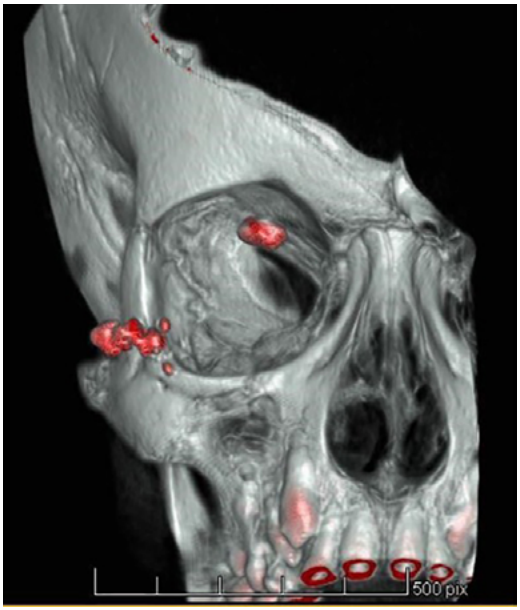


Fig. 15. CT imaging — 3D reconstruction, obtained using the algorhithm reducing metal artifacts and thus facilitating the assessment of foreign bodies.

Fig. 16. The flattened bullet — following the removal from the orbital superior rectus, the buckshot is placed on a round instrument tray. The size of the fragment is ±3 mm in diameter.

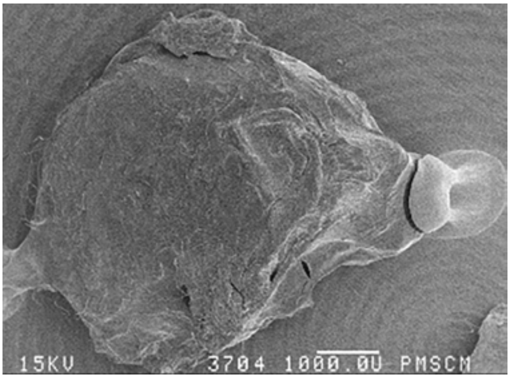


Fig. 17. The reference section = 1000 micrometers.

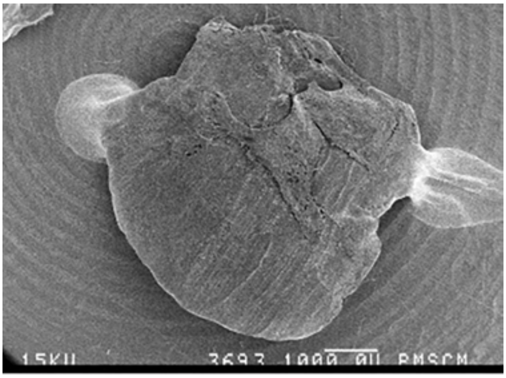


Fig. 18. The reference section = 1000 micrometers.

The scanning microscopy images (authored by K. Świeży, MSc) of two fragments of the bullet extracted from the child's orbit. The fragment of the bullet extracted from the lower part of the wound at the beginning of the second surgical procedure was released to the parents to be shown to the investigative authorities and the police.

Discussion

An injury of the paraorbital region needs a detailed diagnostic management and individually designed therapy. Each patient requires antibiotic therapy because of the high risk of a secondary infection. Organic foreign bodies absolutely require to be surgically removed, while inorganic bodies are predominantly removed in the case of dysfunctions resulting from pressure put on important anatomical structures [1]. The final decision as to the therapeutic mode of the therapy, i.e. conservative versus surgical, should be above all based on the individual current state of the patient determined by means of careful observation of the subject immediately after a foreign body penetrated his orbit and in subsequent hours providing the life of the subject is not directly endangered.

In the described patient, the decisive factors in selecting the therapy included his young age, the chemical composition of the bullet, X-ray-visualized bullet spatter characteristics and the proximity of the optic nerve.

Information on the genesis of the trauma and the origin of the foreign body may be provided by means of taking a detailed medical history solely and exclusively combined with a concomitant and necessary physical examination and an imaging test. The selection of the latter depends on the character of the foreign body (Graph 1). The result is to help in determining the precise course of the foreign body penetration, its final location, a detailed description of the said foreign body and its effect exerted on the surrounding structures and tissues [2] as well as in selecting the approach route to the foreign body that would minimize the risk of complications.

Orbital ultrasonography (Fig. 2) is recommended in the preliminary diagnostic period, yet the method requires extensive experience and access to the newest equipment what may be impossible to achieve in numerous centers [1]. In such instances, the method recommended in the first instance is computed tomography imaging. Nevertheless, the sensitive and aiming at visualization of foreign bodies computed tomography imaging may falsify the images, especially if their size is lower than 0.5 mm or else the foreign body is wood [3]. In such cases, a splendid solution is offered by the possibility of using dedicated algorithms for reduction of metallic artefacts. On the other hand, magnetic resonance imaging is absolutely contraindicated when a ferromagnetic character of the foreign body is suspected.

The final location of the described here foreign body on the borderline of the superior quadrants in the vicinity of the optic nerve and within the topography of the levator palpebrae superior muscle and the superior rectus muscle was confirmed when the clinical picture was taken into consideration (resolution of double vision).

The described here foreign bodies were bullets accidentally fired from an air gun. The excellent result of the surgery contributed to discontinuing the prosecutorial investigation against the parents of the boy and the to a decision to not impose any punishment against them. The presented here therapeutic success is an example of a result achieved by a splendidly cooperating interdisciplinary team which included a radiologist, ophthalmologist, pathomorphologist and laryngologist. It is also a judicial and legal success, since — due to the lack of supervision — the parents faced the punishment consisting in deprivation of the child custody and placing the boy in a foster family. Such a danger appeared at some stage of the investigation.

Conclusions

1. The basis for the surgical success was the perfect radiological diagnostic management allowing for selecting the optimal route of surgical access to the two fragments of the air gun bullet which exploded inside the human body.
2. It is possible to remove a retrobulbary situated foreign body from the orbit at the same time preserving all the functions of the organ of vision.
3. The surgical success led to discontinuance of the prosecutor's proceedings and the decision not to seek penalty against the parents of the boy.

Conflict of interest

None declared.

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