American Journal of Case Reports

e-ISSN 1941-5923
© Am J Case Rep, 2024; 25: e943995
DOI: 10.12659/AJCR.943995

Received: 2024.01.01
Accepted: 2024.09.19
Available online: 2024.10.15
Published: 2024.XX.XX

Non-Surgical Management and Partial Recovery of a 19-Year-Old with Low-Speed Transorbital Penetrating Brain Injury

Authors' Contribution:
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Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
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Financial support: None declared
Conflict of interest: None declared

APPROVED GALLEY PROOF

Patient: Male, 19-year-old
Final Diagnosis: Trans-orbital penetrating injury
Symptoms: Kinetic cerebellar syndrome • nystagmus • trigeminal neuropathy
Clinical Procedure: —
Specialty: Anatomy • Neurology • Neurosurgery • Radiology

Objective: Unusual clinical course

Background: Clinical management of intracranial transorbital penetrating injury (TOPI) is challenging and may require surgery. Both the trauma and surgery can result in neurovascular damage, bleeding, and infection. Low-speed injury may involve the superior orbital fissure (SOF) as the main point of entry into the skull and is associated with lower morbidity than high-speed injuries. This report describes a 19-year-old man with pontine and left cerebellar involvement from a TOPI with partial recovery without surgery.

Case Report: We hereby report the case of a 19-year-old man who underwent a low-speed *in-out* (as the foreign body was immediately retrieved) deep transorbital pontine and left cerebellar penetrating injury. Despite transient loss of consciousness, his Glasgow Coma Scale at admission was 15. An intravenous antibiotic regimen was rapidly initiated. He had ophthalmic (V1) et maxillary (V2) nerves palsy, minor right pyramidal syndrome, and left kinetic cerebellar syndrome. Multi-modal imaging perfectly correlated with the clinical presentation. Neither surgical nor angiographic management was required. Clinical evolution was favorable, and the patient partially recovered.

Conclusions: In case of penetration through the SOF, the clinical course tends to be benign. However, this case should not overshadow potential life-threatening complications of TOPIs. This report highlights the importance of a multidisciplinary approach for the diagnosis and management of traumatic transorbital penetrating intracranial injury. As illustrated, medical imaging may demonstrate the exact pathway of the offending object.

Keywords: Brain Hemorrhage, Traumatic • Cranial Nerve Injuries • Craniocerebral Trauma

Full-text PDF: https://www.amjcaserep.com/abstract/index/idArt/943995

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Introduction

Non-projectile-related (as opposed to high-velocity projectile injuries) transorbital penetrating injuries (TOPIs) are uncommon but a few case reports or small series have been published since the late 1990s. A brief meta-analysis of published individual case reports [1-13] and small series [14-19] shows that TOPIs occur at any age (from 2 to 83 years old) and are more frequently reported in men (sex ratio 3: 1). In reported cases of fall, assault, accident, or self-inflicted injuries [3,8,17], a wide range of foreign bodies are involved, from wooden (chop)sticks [4,6,7,9,15,16,18], pens [8,17], nails [11], and metal bars [14,19], to more surprising objects such as combs [5], toothbrushes [20], door keys [2], hunting arrows [1], or windshield wipers [17].

Clinical presentation can be very subtle [21] and depends on the involved structures within the orbit or the posterior fossa, including cranial nerves injuries, hemiparesis/hemiplegia, and cerebellar syndrome [9]. Even in case of TOPIs affecting the brainstem, outcomes are better compared to ballistic high-velocity injuries caused by bullets or shrapnel that breach the skull [22,23], where tissue damage is secondary to heat dissipation instead of mere tissular laceration [21]. Nonetheless, depending on vascular lesion occurrence as well as the size, composition, and penetration depth of the offending object, lethal outcomes are reported [14-16,18,19].

Complications depend on the penetrating route taken by the foreign object and thus on the anatomical structures crossed by the object [21]. Three main penetrating routes are described [8]: through the superior orbital fissure (SOF, 62% of cases, explained by the pyramidal shape of the orbit, orienting penetrating objects towards the orbital apex) [5-7,9,15,16], through the optic canal, or through the thin and fragile orbital roof. In contrast, penetration through the orbital floor is rare [21] and, as suggested by Lasky et al [20], the lateral aspect of the orbit is almost never involved because of the avoidance head turn, especially in self-inflicted trauma.

This report describes a 19-year-old man with pontine and left cerebellar involvement from a TOPI with partial recovery without surgery.

Case Report

A 19-year-old man, with no particular medical history, suffered from an accidental orbital injury as he was enjoying a drinking party. As he was constantly peeping through a keyhole, one of his annoyed friends suddenly and blindly introduced, then immediately retrieved, a broken riding crop consisting of the approximatively 50-cm-long shaft with no keeper through the keyhole. Witnesses were immediately alerted by the sound of the patient falling down behind the door. Later, they claimed that they found the patient unconscious and there was no external bleeding. The patient regained consciousness before ambulance arrival and was immediately admitted to a local hospital with a Glasgow Coma Scale (GCS) score of 15. Prophylactic intravenous antibiotic therapy (ceftriaxone 2 g twice a day) was initiated.

Two days later, he was transferred to our institution. The eyelids were intact. He had a left temporal headache, ataxic gait, and incoordination of the left arm and hand. At ocular examination, the left ocular globe was intact, with normal pupil response and preserved visual acuity. There was no exophthalmia, oculomotor impairment, or cerebrospinal fluid leakage. Neurologic assessment showed full consciousness (GCS 15) and a left kinetic cerebellar syndrome with slight left nystagmus, a subtle right pyramidal syndrome, and hypoesthesia in the ophthalmic (V1) and maxillary (V2) territories of the left 5th cranial nerve (CN-V, trigeminal nerve). There was no sign of meningitis. Biological investigations were unremarkable.

Cerebral computed tomography (CT) (**Figure 1**) revealed a 16-cm-long linear penetrating injury from the infero-medial aspect of the left orbit to the left occipital bone, without hemorrhagic complication nor fracture. Trajectory analysis based on clinical and imaging findings allowed accurate description of the penetrating route. The shaft of the crop entered the orbit alongside the infero-medial margin of the ocular globe and exited trough the superior orbital fissure, penetrating the Meckel's cave alongside the lateral aspect of the cavernous sinus. It then ran within the left part of the prepontine cistern and into the lateral part of the pons, medial to the emergence of the left CN V. From there, it followed its course through the left middle cerebellar peduncle, alongside the left wall of the fourth ventricle and in the para-median part of the left cerebellar hemisphere (anterior lobe and upper part of the posterior lobe). Ultimately, the course of the foreign body was interrupted by the inner table of the occipital bone, just below the cerebellar tentorium and the left transverse sinus.

Brain magnetic resonance imaging (MRI) (**Figure 2**) confirmed the integrity of the cavernous sinus and cavernous portion of the internal carotid artery. Linear pontine and cerebellar hemorrhagic changes in keeping with the penetrating trajectory of the crop's shaft were observed.

Prophylactic antibiotic therapy was interrupted 2 weeks after initiation. Upon satisfying clinical evolution, the patient was released 16 days after the injury. Neither surgical nor interventional exploration was required.

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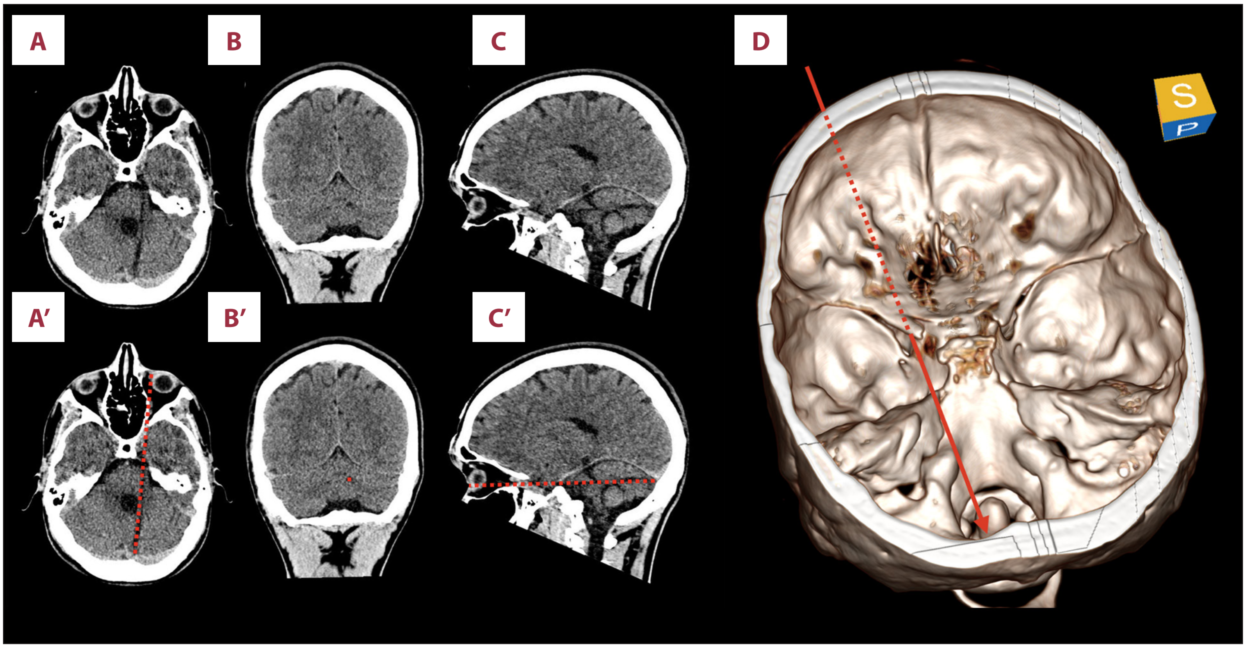

Figure 1. Brain computed tomography scan, subacute phase (2 days after injury). Axial (**A**), coronal (**B**), and sagittal (**C**) reconstructions in the plane of the penetrating trajectory. Corresponding series **A', B',** and **C'** depict the left linear foreign body route (red dotted line) through the orbit, the superior orbital fissure, the Meckel's cave, the prepontine cisterna, the lateral part of the pons, the middle cerebellar peduncle, and the left cerebellar hemisphere. (**D**) Volume-rendering technique, three-dimensional trajectory reconstruction.

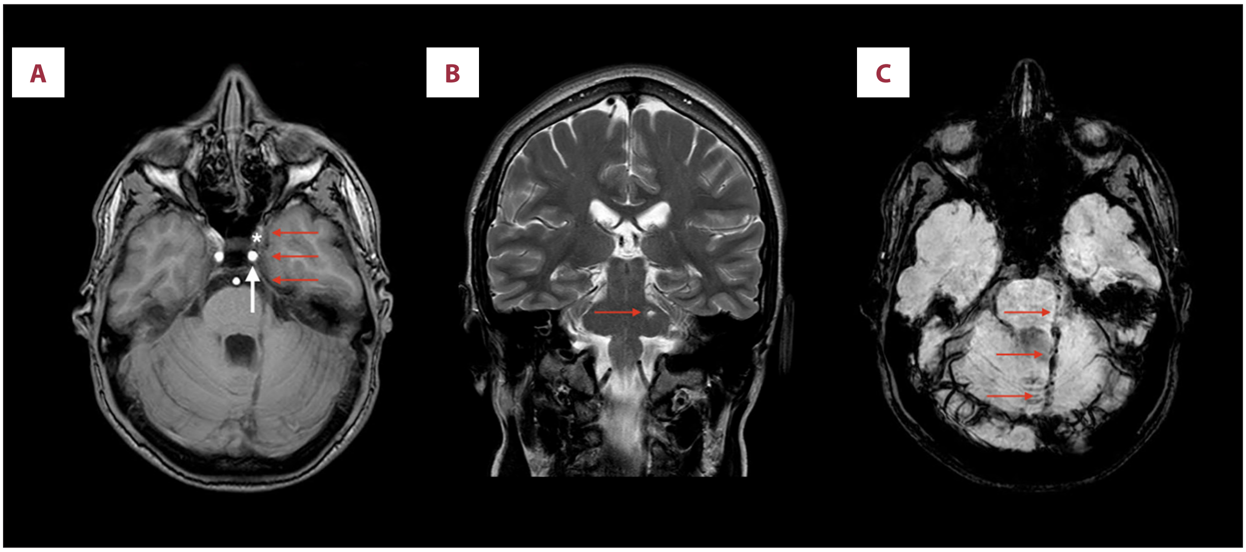

Figure 2. Follow-up brain magnetic resonance imaging (16 days after injury). The penetrating route is marked by the red arrows. (**A**) Axial post-contrast T1-weighted acquisition showing the proximity of the foreign object penetrating through the Meckel's cave (*cf*. cranial nerve V1 injury) with the C4 portion of the left internal carotid artery (white arrow) inside the cavernous sinus (white asterisk). (**B**) Coronal T2-weighted acquisition pointing at the "punched hole" lesion in the upper left part of the pons. (**C**) Axial susceptibility-weighted imaging (maximum intensity projection) depicting subtle hemorrhagic changes alongside the posterior fossa parenchymal portion of the penetrating route (left upper part of the pons and superior part of the left cerebellar hemisphere accounting for the left kinetic cerebellar syndrome).

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The 4-year follow-up demonstrated left frontal and periorbital hypoesthesia in keeping with a lesion of CN V1. The patient also had a left segmental kinetic tremor [24] and dysmetria as part of a left kinetic cerebellar syndrome, related to the left middle cerebellar peduncle and hemisphere lesions. Neither direct carotid-cavernous fistula nor carotid pseudoaneurysm were observed.

Discussion

As highlighted in this reported case, the entry route of a transorbital penetrating object might be an important prognostic factor. Via the medial canthus, the penetrating course through the SOF at the orbital apex tends to direct the penetrating object laterally, towards the cavernous sinus, and, if long enough, to the lateral aspect of the pons. This stereotypical anatomical pathway often results in non-lethal outcomes and minimal morbidities [9].

To the best of our knowledge, the present description is one of the few reported cases of TOPI with immediate removal ("*in-out*" mechanism) of the foreign object. Only Chowdury et al [16] and Schwark et al [10] reported cases of TOPI where the penetrating foreign object could not be found in situ, even after brain imaging. We should keep in mind that, even if not retrieved, the foreign object can initially go undetected, especially in the pediatric population [13]. In case of unobtrusive or missing entry wound and lack of anamnestic information, the hypothesis of intracranial injury could be neglected, leading to misdiagnosis and avoidable complications. Determining the exact injury mechanism might even require forensic analysis [10].

This case is remarkable by the lack of severe injury for such a long and straight-forward *in-out* transorbital penetrating route through highly functional anatomic areas (**Table 1**). It is worth noting that preserved consciousness (GCS 15) was a factor of good prognosis. By its benign course, the case perfectly illustrates the "safe route" provided when the trajectory goes through the SOF, as opposed to an entry point through the optic canal or direct penetration through the orbital roof [14]. The ocular globe was unharmed. Indeed, in such low-velocity non-missile penetrating traumatisms (defined as an impact velocity <100 m/s [17]), the ocular globe is displaced within orbital fat by incoming foreign objects rather than injured.

The crossing of the SOF, allowing penetration of the cranial cavity without orbital fracture, left the oculomotor nerves uninjured. The absence of vascular traumatic lesions is of the utmost interest, as the shaft of the crop went through the orbit without injuring the ophthalmic artery (and its multiple branches), just shy of the cavernous portion of the internal carotid artery, 12 mm lateral to the basilar trunk, and its occipital impact wa just millimeters below the left transverse sinus.

Clinical features perfectly correlated to imaging-detected injured structures (**Table 1**). Partial trigeminal hypoesthesia is most likely due to lesions of its V1 and V2 branches into the Meckel cave, where Gasser's ganglion lies at the reunion of its 3 sensitive branches. A central lesion (partial lesion of the pontine principal sensory nucleus of the trigeminal nerve) is another feasible theory. A subtle right pyramidal syndrome is in keeping with the involvement of the left cortico-spinal tract above the level of the decussation in the medulla. The left kinetic cerebellar syndrome is explained by the lesions of the left cerebellar peduncle and cerebellar hemisphere.

Beside the relatively benign course of this case, it must be kept in mind that TOPIs are also responsible for severe traumas, and lethal outcomes are reported [14-16,18,19]. As for all penetrating cranial injuries, the main prognostic factors are the GCS score at admission and the presence of midline structures injuries [19,25]. Medical teams should anticipate life-threatening complications. Infectious complications are the most prevalent (up to 70% of cases) and lethal (mortality rate ranging from 14% to 57%) complications of TOPIs [26]. These infections, such as meningitis and abscesses [4], mainly develop when organic (such as wood) and/or fragmented materials are involved [4,21]. *Staphylococcus aureus* is the more prevalent pathogen, but gram-negative bacteria are also commonly reported [26,27]. Generally, 7 to 14 days of antibiotic prophylaxis is advised [27] upon admission [17].

The rate of vascular complications following TOPIs, such as internal carotid artery dissection with subsequent occlusion/pseudoaneurysm or carotid-cavernous fistula, is estimated at 50% in various publications [28], but some authors report these complications are rare [29,30]. These conflicting data might be explained by the variable course of the foreign object involved. Indeed, the penetrating route matters a great deal pertaining to this point, as a pathway through the SOF orientates the penetrating object lateral to the cavernous sinus, thus avoiding the internal carotid artery, as opposed to the less frequent trajectory through the optic canal directing the foreign body towards the cavernous sinus [13].

Hemorrhagic complications can either be extra-axial (epidural hematoma or subarachnoid hemorrhage) or intra-axial (intracerebral hemorrhage). Hematomas can result from direct brain injury independently from the presence of vascular injuries [31].

Other non-life-threatening reported complications include cerebrospinal fluid leakage, cranial nerve injury depending on the penetrating route, and a wide range of neurological defects depending on the affected brain area(s) [11,12]. Penetrating brain injury leads to complex neurotrauma pathomechanisms, from neuronal and glial damage to blood-brain barrier impairment,

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Table 1. Summary of involved anatomical regions and their injured or undamaged components alongside the penetrating course of the injury.

Anatomical region	Structure	Relevant injured content *and normal function*	Relevant undamaged content at the level of injury	*Notes*
Orbit			• Ocular globe • Medial rectus muscle • Optic nerve (CN II) • Ophthalmic artery	
Superior orbital fissure			• Common oculomotor nerve (CN III) • Trochlear nerve (CN IV) • Abducens nerve (CN VI)	
Middle fossa	Meckel's cave	**Ophthalmic nerve (CN V1)**[#] *Ipsilateral sensory innervation to the eye and the upper-face (upper eyelid, forehead, and anterior scalp)* **Maxillary nerve (CN V2)** *Ipsilateral sensory innervation to the nasal cavities, sinuses, palate and midface (from upper lip and upper dental arch to lower eyelid)*	• Gasserian ganglion • Mandibular nerve (CN V3)	*Just medial to Meckel's cave lies the cavernous sinus containing CN III, CN IV, CN V1, CN V2, CN VI and the C4 portion of the ICA*
Posterior fossa	Pre-pontic cistern		• Basilar trunk • CN V (common sensory root)	
	Pons	**Pyramidal tract** *Contralateral upper motoneurons fibers* **CN V main sensory nucleus*** *Epicritic (touch-pressure) sensation of the face*		** is an alternative plausible theory explaining the hypoesthesia observed in CN V1 and CN V2 territories.* *NC CN VI, VII and VIIbis nuclei are located lower within the pons*
	Middle cerebellar peduncle	**Cerebellum afferent pathways** (superior, inferior and deep fasciculi)		
	Cerebellar hemisphere	**Anterior cerebellar lobe**[#] *Also called "paleocerebellum", the anterior lobe is thought to be involved in unconscious proprioception*		
		Posterior cerebellar lobe[#] *Also called "neocerebellum", the posterior lobe is thought to be involved in motor coordination*		

[#] Incomplete recovery. CN – cranial nerve; CN II – optic nerve; CN III – common oculomotor nerve; CN IV – trochlear nerve; CN V – trigeminal nerve; CN V1 – ophthalmic division of the trigeminal nerve; CN V2 – maxillary division of the trigeminal nerve; CN V3 – mandibular division of the trigeminal nerve; CN VI – *abducens* nerve; ICA – internal carotid artery.

subsequent gliosis and ultimately physiological and behavioral changes. Multiple external and internal (genetic, age, sex) factors are likely to influence the outcome but remain unclear [32]. Epilepsy develops in up to 50% of cases [3].

Use of blind retrieval of the foreign body is strongly discouraged [1,14] as vascular injury may be self-compressing. Optimal management requires a multidisciplinary approach and a comprehensive radiological work-up [18] to define the accurate trajectory of the penetrating object, exclude vascular complications, and assess foreign body integrity and composition. In case of suspected or documented vascular injury, angiographic assessment is recommended, and embolization might be required to reduce bleeding risk and mortality [13,33]. In the second phase, removal of the foreign object should be carefully planned. Depending on cases and teams, neurosurgical transorbital and/or transcranial approach may be considered, but craniotomy is classically required to allow direct visualization of the intracranial foreign body and its safe and complete retrieval. Cautious exploration and debridement are mandatory to retrieve all potential fragments to reduce risk of infectious complications. Evacuation of potential hematoma with thorough hemostasis and cautious dural closure are mandatory [14]. Planned external removal of the foreign body has been described after imaging work-up [8,12,19]. Early follow-up brain imaging should be considered to assess brain damage, best visualized once the object is retrieved, and to rule out any secondary hematoma [14]. Carotid-cavernous fistula and traumatic aneurysms are possible late-onset complications, emphasizing the need of long-term clinical and radiological follow-up [5,30].

Conclusions

TOPIs are a rare subset of craniofacial traumas. In case of low-velocity penetrating injury, the SOF is the main entry point into the skull vault and poses less risk of nervous and vascular injury compared to other penetrating routes. Comprehensive knowledge of the anatomy of the orbital apex and the cavernous sinus is key to manage such cases. The clinical course is frequently benign but should not overshadow the potential poor outcomes of transorbital and intracranial penetrating injuries. This report highlights the importance of a multidisciplinary approach and dedicated radiological work-up in management of traumatic transorbital penetrating intracranial injury.

Acknowlegements

We thank the patient and his family for their trust, as well as L. Collignon, MD and A. Maertens-De Noordhout, MD, PhD for their support.

Institution Where Work Was Done

Citadelle Hospital, Liège, Belgium.

Declaration of Figures' Authenticity

All figures submitted have been created by the authors who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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