Korean J Neurotrauma. 2023 Sep;19(3):363-369
https://doi.org/10.13004/kjnt.2023.19.e48
pISSN 2234-8999·eISSN 2288-2243

KJNT

Case Report

Fencing Knife-Induced Transorbital Penetrating Brain Injury: A Case Report

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Received: Jul 25, 2023
Revised: Aug 30, 2023
Accepted: Sep 1, 2023
Published online: Sep 21, 2023

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Conflict of Interest
The authors have no financial conflicts of interest.

ABSTRACT

Penetrating brain injury (PBI) is a rare type of traumatic brain injury, which accounts for 0.4% of all head trauma cases. In this study, we describe a 14-year-old male adolescent who sustained a transorbital penetrating injury caused by a fencing knife. Although the patient visited the hospital after the foreign body had been removed, we diagnosed a PBI based on identification of a linear injury trajectory extending from an orbital roof fracture to the contralateral parietal lobe, using three-dimensional reconstruction of the hemorrhage. The patient fully recovered after conservative treatment. We hope that sharing our experience will serve as a guideline for the clinical management of PBI.

Keywords: Traumatic brain injury; Penetrating brain injury

INTRODUCTION

Penetrating brain injuries (PBIs) account for only 0.4% of head trauma cases and are extremely rare.[25] Transorbital PBIs enter the intracranial space through the sphenoidal and frontal bones constituting the orbit. Because these sphenoidal and frontal bones are more fragile than other cranial vaults, transorbital PBIs account for 24% of adult PBIs and 45% of children.[24] PBIs usually result from falls or traffic accidents and children engaged in inappropriate play.[17] Many cases of PBI have been reported, and the types of foreign bodies include wooden objects such as chopsticks and thin metal objects such as forks, knives, and umbrella tips.[18] Most neurosurgeons treat PBIs based on their experience and institutional guidelines.[17] In the present case, the patient sustained a transorbital penetrating injury caused by a fencing knife and managed with conservative treatment.

CASE REPORT

The patient, a 14-year-old male, had collapsed at the fencing ground and been transported to the hospital emergency room in Dubai by ambulance. The patient was not injured during an official match, but was injured while playing with a friend with a fencing knife without wearing facial protective gear. Bruising and swelling were observed in the patient's right eye. Loss of consciousness lasted 15-20 minutes after the injury. The patient had no relevant medical history. Upon arrival at the hospital, a neurologic examination revealed a Glasgow Coma Score (GCS) of 13/15; both pupils were 2 mm/2 mm prompt, but the right side's motor was 0. A right-eye periorbital hematoma and right-sided unilateral proptosis with a pre-septal hematoma were observed. He appeared to have difficulty opening his eyes and experienced adductive paralysis.

Initial brain computed tomography (CT) performed in Dubai showed intraventricular hemorrhage (IVH) on both lateral ventricles and a longitudinal contusion with pneumocephalus in the parietal lobe (**FIGURE 1A-F**). And angio-CT revealed no major artery damage (**FIGURE 1G**).

Three-dimensional (3D) CT showed a fracture (**FIGURE 1E** white arrow, **FIGURE 2** arrowheads) on the medial side of the superior orbital fissure (**FIGURE 2**, white arrow) and optic canal (**FIGURE 2**, black arrow). Although there was no foreign body remaining in the intracranial space, we assumed that the fencing knife penetrated the orbital wall and reached the contralateral parietal lobe. Our assumption was verified in the intracranial hemorrhage 3D reconstruction by trajectory leading from the orbital entrance to the contralateral parietal lobe (**FIGURE 3**). A 3D reconstruction was performed using the 3D Slicer Program (http://www.slicer.org).

The patient was admitted to the intensive care unit and received conservative treatment. The patient was administered an antiepileptic, levetiracetam (500 mg every 12 hours), and covered with the prophylactic antibiotics ceftriaxone and metronidazole.

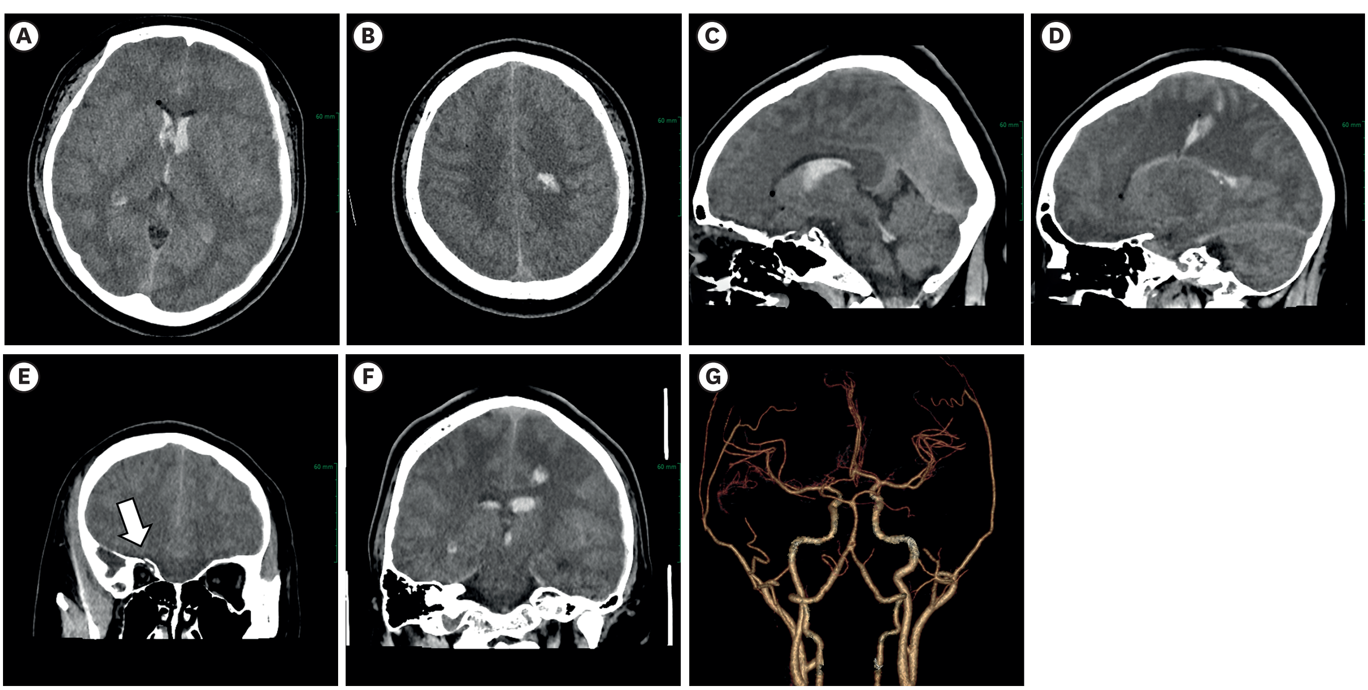

FIGURE 1. Initial brain CT of patients with transorbital penetrating brain injury. (A-F) An initial CT shows a longitudinal contusion extending from the right frontal lobe to the left parietal lobe with intraventricular hemorrhage. Fractures of the orbital roof were also observed (E, white arrow). (G) CT angiography revealed no major artery damage.
CT: computed tomography.

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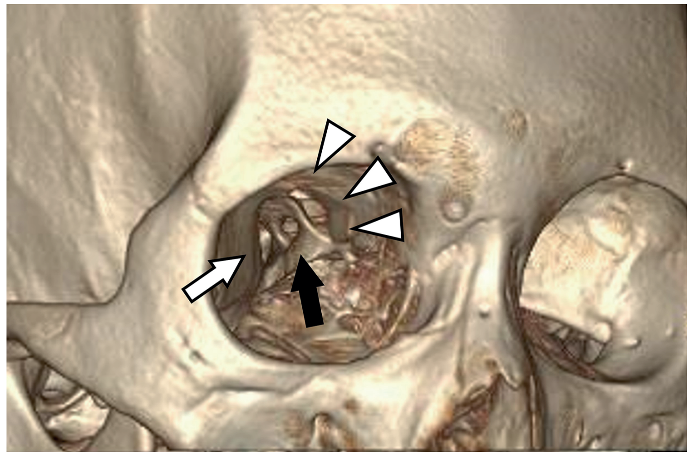

FIGURE 2. Three-dimensional computed tomography showing an orbital roof fracture. The intracranial entrance created by the fracture (arrowheads) is observed on the medial side of the superior orbital fissure (white arrow) and optic canal (black arrow).

He developed a fever (maximum 38.6°C) with several spikes after hospital day 7. An infectious-disease team recommended switching antibiotics to meropenem and vancomycin. On brain CT follow-up the next day, IVH and pneumocephalus had resolved. After a few days, the patient was alert, the GCS score was 15/15, and inflammatory markers had settled. After 9 days, contrast-enhanced magnetic resonance imaging revealed leptomeningeal enhancement, suggestive of meningitis (FIGURE 4).

One month after the initial injury, the patient was transferred to our hospital. The right motor function was grade 4 and ankle flexion was grade 1 on neurological examination. Ophthalmologic examination showed no damage to the patient's eyeball, and no abnormalities were found in visual field or visual acuity examination. The patient had no fever and inflammatory marks were within the normal range. The patient was transferred to the Department of Rehabilitation Medicine. A slight enlargement of the ventricles was observed on the last CT scan, but most of the patient's neurological deficits were improved after rehabilitation, and no hydrocephalus symptoms were observed. The patient was discharged without any particular neurological deficit after 1 month of rehabilitation treatment.

This study was conducted in accordance with the Declaration of Helsinki and approved by the local ethics committee (2023-09-016). The requirement for informed consent was waived because of the retrospective nature of this study.

DISCUSSION

PBIs are divided mainly into missile and non-missile projectiles; the average speed is 100 m/s.[3] The reason for this division is that non-missiles cause only laceration and maceration wounds; missiles, such as gunshots, cause increased intracranial damage due to high-speed kinetic and thermal energy.[2,4,6] Most non-missile PBIs are caused by knives or cutting tools.[20]

In PBIs, the trajectory of the penetrating objects has a significant effect on brain damage.[25] The skull, orbits, nasal cavities, and oral cavities are the main openings in PBIs.[10] Among them, trans-orbital injury occurs through penetration of the superior orbital fissure, optic

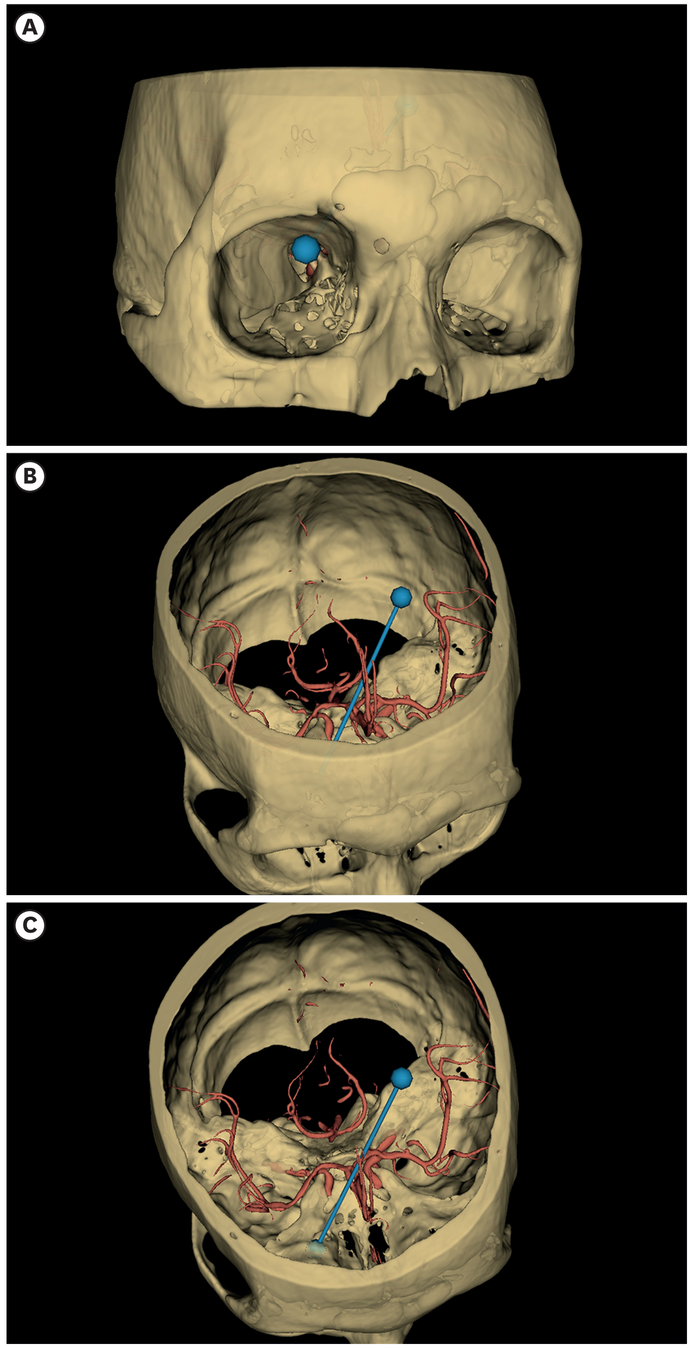

FIGURE 3. Three-dimensional reconstruction of intracranial hemorrhage. Reconstruction images show a longitudinal contusion extending from the right frontal lobe to the left parietal lobe.

canal, and orbital roof.[21,25] Because falls are often caused by being stabbed directly upward by a penetrating object, the most common damage to the frontal lobe is through the orbital roof.[13] As in this case, the superior orbital fissure is penetrated the next most frequently. A low-velocity object passes through the superior orbital fissure and pyramidal orbital bone structure, damaging the cavernous sinus, lower frontal lobe, medial temporal lobe, upper petrous ridge, and lateral side of the brainstem.[12,14] This case is a rare example in which a flexible fencing knife damaged the contralateral motor cortex through the lateral ventricle

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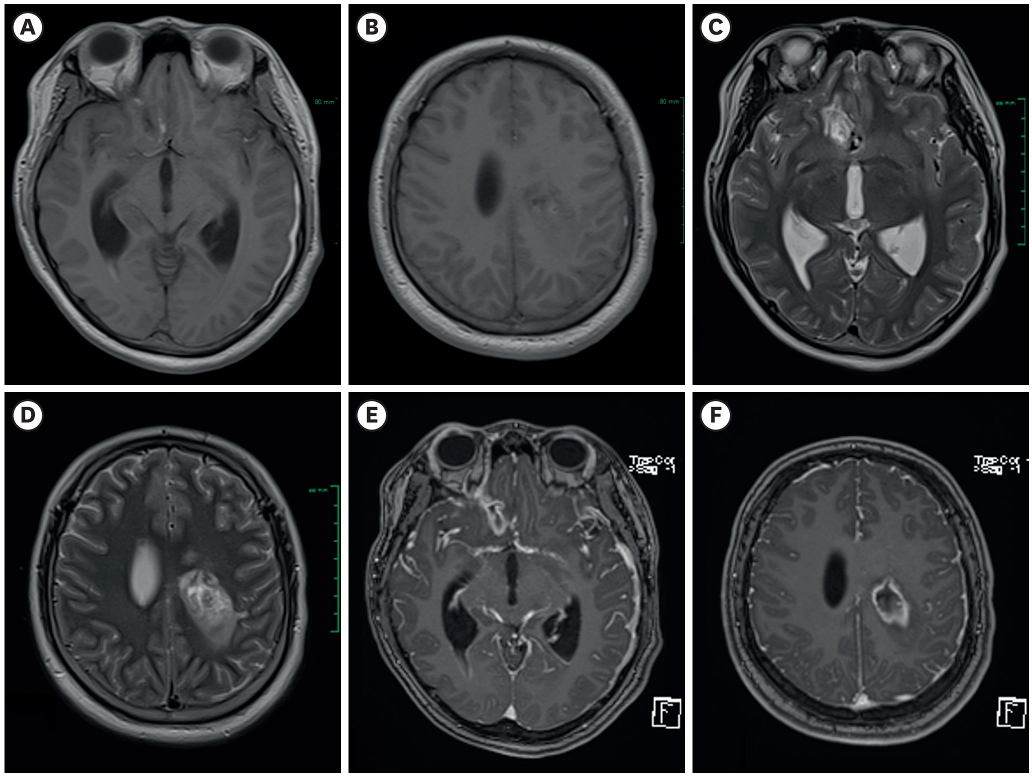

FIGURE 4. Contrast-enhanced magnetic resonance imaging showing leptomeningeal enhancement suggestive of meningitis. (A, B) T1-weighted images show hemorrhage with intermediate signal intensity. (C, D) T2-weighted images show hemorrhage with high signal intensity. (E, F) Leptomeningeal enhancement is observed in T1-weighted images with contrast.

instead of using a superior orbital fissure penetration trajectory. A trajectory through the optic canal can directly affect the suprasellar cistern, optic nerve, and internal carotid artery.[13)]

Like all patients with trauma, those with a PBI must receive advanced trauma life support.[18)] Treatment of a PBI is divided into a stage in which the foreign body is removed and a stage in which the foreign body is intact. If the foreign body has already been removed before the patient arrives at the emergency room, serious neurological sequelae tend not to occur.[1)] Nonetheless, the neurosurgeon must make a decision based on a thorough clinical and radiological evaluation, whether to perform only conservative treatment or add surgical treatment. Even if foreign substances are removed, intradural invasion can be caused by external bacteria; therefore, the guidelines recommend the use of prophylactic antibiotics.[7,15,24)] In previous studies, intravenous injection of cefazolin (1 g every 8 hours) or ceftriaxone (2 g every 24 hours) for 5 days was recommended for a PBI. Administration of 500 mg of metronidazole every 6–8 hours can be added to account for anaerobic bacteria in injuries caused by organic debris.[7,15,24)]

If a patient arrives at the emergency room with a foreign body that has penetrated the brain, surgical treatment should be considered for foreign body removal. Prior to surgery, a thorough radiologic evaluation of major vessel damage is required.[22,23)] These procedures are performed to select an approach that minimizes intraoperative brain damage since vascular damage is common in PBIs. Even if major vessel damage is not observed on imaging, the penetrating foreign body should not be blindly removed from a place other than the operating room.[11,19)] In order to cope with bleeding of major vessels or their branches that

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may occur after removal of the foreign body, the penetrating foreign body must be removed in the operating room.

Patients with a PBI and optic nerve injury complications typically receive high-dose steroids.[26)] In addition, if infectious complications are present, prophylactic antibiotics and tetanus vaccination are recommended because the risk of antibiotic treatment is less than that of infection.[18,24,26)] Wood, in particular, is a porous organic material and can be a good medium for bacteria and meningitis-causing organisms.[25)] Especially in these cases, antibiotics are important because brain abscesses can be easily induced. Other complications include cerebral complications (e.g., cerebral contusions, intracerebral hematoma, and pneumocephalus) and vascular complications such as pseudoaneurysm and post-traumatic caroticocavernous fistula.[24)]

In this paper, we focus on treatment after PBI. On the other hand, preventing PBI is just as crucial as treating it. It is already well-known that protective headgear can reduce the risk of head trauma in sports or transportation.[5,8,9,16)] Our case could have been prevented if the patient had worn a protective headgear.

CONCLUSION

This case was significant because the damage occurred in a trajectory different from the general superior orbital fissure. Transorbital PBIs are rare, especially from a fencing knife injury, and occur in many types; therefore, a careful history review and radiological evaluation are required. However, this requires proper treatment and observation.

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