Transorbitary intracranial penetrating injury involving bicycle brake handle: case report and literature review

Lesão penetrante intracraniana transorbitária envolvendo manete de freio de bicicleta: relato de caso e revisão da literatura

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ABSTRACT

Penetrating cranio-orbital injuries are uncommon events and represent a small percentage of cranioencephalic traumas. The clinical condition and surgical management were described by reviewing the patient's electronic medical records. This case reports on a 37-year-old male patient who suffered penetrating trauma to the skull from the brake lever of his bicycle as a result of an accidental fall while cycling. Brought in by the SAMU, the patient had a Glasgow score of 15, a preserved left orbit, while the right orbit showed no eye opening, amaurosis, a non-photo-reagent mydriatic pupil, both to the direct and indirect reflex. A computed tomography scan of the skull showed a metal brake handle lodged in the skull on the right, causing a fracture of the orbital face of the zygomatic and greater wing of the sphenoid, with the end in the orbit. In the operating room, the object was carefully extracted without complications. On the first postoperative day, a magnetic resonance imaging scan was requested, which revealed a hemorrhagic contusion of the temporal lobe on the right side, rupture of the lateral rectus muscle, hematic and gaseous contents inside the orbit, as well as a possible retinal detachment. On the sixth post-operative day, with amaurosis maintained on the right, the patient was discharged and referred for specialized ophthalmological follow-up. Penetrating cranio-orbital trauma has potentially fatal outcomes if not diagnosed and managed early and properly.

RESUMO

Ferimentos penetrantes crânio-orbitário são eventos pouco comuns e representam uma pequena porcentagem dos traumas craniencefálicos. A descrição da condição clínica e o manejo cirúrgico foram realizadas a partir da revisão do prontuário eletrônico do paciente. O presente relato é do caso de um paciente do sexo masculino, de 37 anos, que apresentou trauma penetrante em crânio pelo manete de freio de sua bicicleta, devido à queda acidental enquanto pedalava. Trazido pelo SAMU, o paciente apresentava escore de Glasgow 15, órbita esquerda preservada, enquanto na órbita direita, observou-se ausência de abertura ocular, amaurose, pupila midriática não fotorreagente, ao reflexo direto e indireto. Na tomografia de crânio, visualizou-se manete de freio metálico alojado no crânio à direita, promovendo fratura da face orbital do zigomático e asa maior do esfenoide, com extremidade na órbita. No centro cirúrgico, a extração cuidadosa do objeto foi realizada sem complicações. No primeiro dia de pós-operatório, foi solicitada ressonância magnética que discriminou, do lado direito, contusão hemorrágica do lobo temporal, ruptura do músculo reto lateral, conteúdo hemático e gasoso no interior da órbita e possível descolamento de retina. No sexto dia de pós-operatório, foi mantida amaurose à direita. O paciente recebeu alta e foi encaminhado para acompanhamento oftalmológico especializado. Traumas penetrantes crânio-orbitário apresentam desfechos potencialmente fatais se não diagnosticados e manejados precoce e adequadamente.

INTRODUCTION

Penetrating cranio-orbital injuries make up a small percentage of head trauma and are rare events in the civilian population. They are commonly associated with fragments scattered at high speed, such as firearms or explosions.[1,2] However, penetrating injuries can occur with objects thrown at low speed, commonly associated with a fall towards the object.[2-4]

This study was approved by the Research Ethics Committee of the Centro Universitário Padre Albino, under CAAE 76156823.7.0000.5430 and consubstantiated protocol 6.548.133. The Case Report (CARE) guidelines were followed in the preparation of this report.

CASE REPORT

A 37-year-old white male patient fell while riding a bicycle. During the accident, the brake lever penetrated the skull in the region of the lateral wall of the right orbit (Figure 1A). He was admitted to the emergency department by the Emergency Medical Services (SAMU - Serviço de Atendimento Móvel de Urgência), with stable vital sign. Neurological examination revealed a Glasgow score of 15, a photo reagent left pupil and no loss of visual field, absence of right eye opening and amaurosis, with a non-photo reagent mydriatic pupil, both to the direct and indirect reflex.

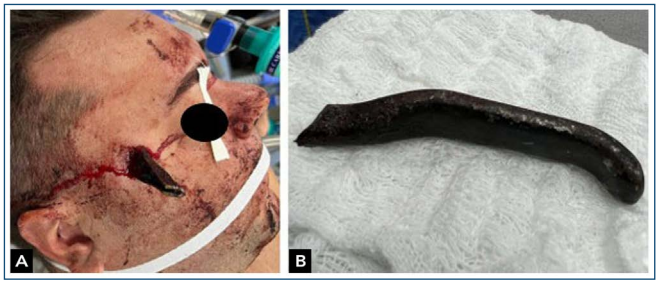

Figure 1. (A) Patient with penetrating object (bicycle brake lever) located in the lateral aspect of the right orbit. (B) Foreign body removed after surgery.

As an initial course of action, an emergency computed tomography (CT) scan was ordered, as well as monitoring and peripheral venous access, tetanus prophylaxis, antibiotic prophylaxis with ceftriaxone and clindamycin, fibrinolytics, antiemetics, analgesics, corticosteroids, laboratory tests, and referral to the operating room.

A CT scan showed that the thoracic and cervical segments were preserved. Images of the skull showed a metallic foreign body lodged in the skull on the right, where it caused a fracture of the orbital face of the zygomatic and greater wing of the sphenoid (Figure 2). Laboratory tests were unchanged.

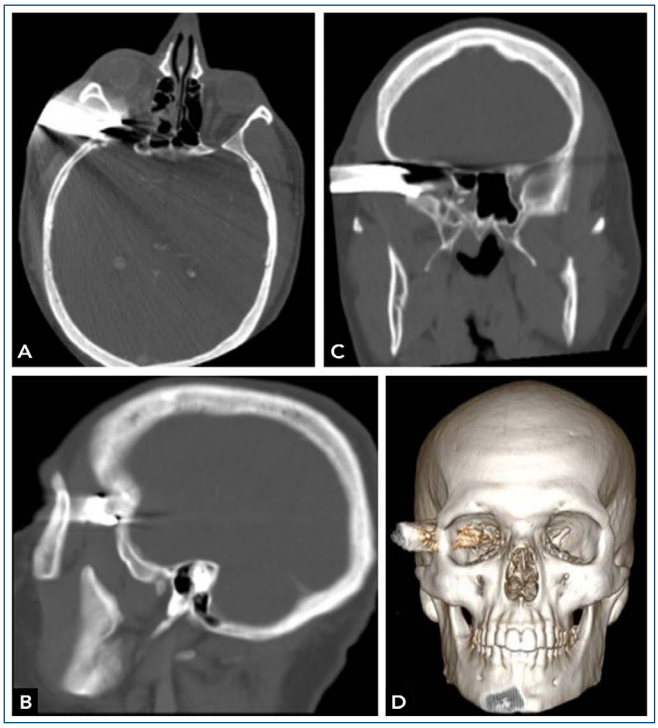

Figure 2. Bone window computed tomography image in the axial (A), sagittal (B), coronal (C) and volume rendered (D) planes showing a metallic foreign body lodged in the skull on the right, causing a fracture of the orbital face of the zygomatic and greater wing of the sphenoid, with the tip in the orbit.

During surgery, the surgical incision was extended around the lesion, and the brake lever was carefully removed (Figure 1B), the area was cleaned with saline solution and the area was closed with the appropriate sutures. The patient was referred to a critical intensive care unit (ICU) bed, maintaining hemodynamic stability. Antibiotic and corticoid therapy were maintained, and anticonvulsants were prescribed.

On the first postoperative day, the patient was oriented and communicative. Physical examination revealed amaurosis on the right. The patient was discharged to the ward, and bilateral magnetic resonance imaging (MRI) of the orbits with contrast was requested (Figure 3). The MRI showed a hemorrhagic parenchymal contusion located in the anterolateral aspect of the right temporal lobe, edema, and heterogeneity of the orbital and periorbital fat on the right, with probable gaseous content, presence of discrete content located in the posterior aspect of the right eyeball, suggesting hematic content, without typical morphology, but which may correspond to retinal detachment. Optic nerves showed preserved morphology and signal.

On the fifth post-operative day, the patient was discharged from hospital. Te right-sided amaurosis remained, and the patient was referred for specialized

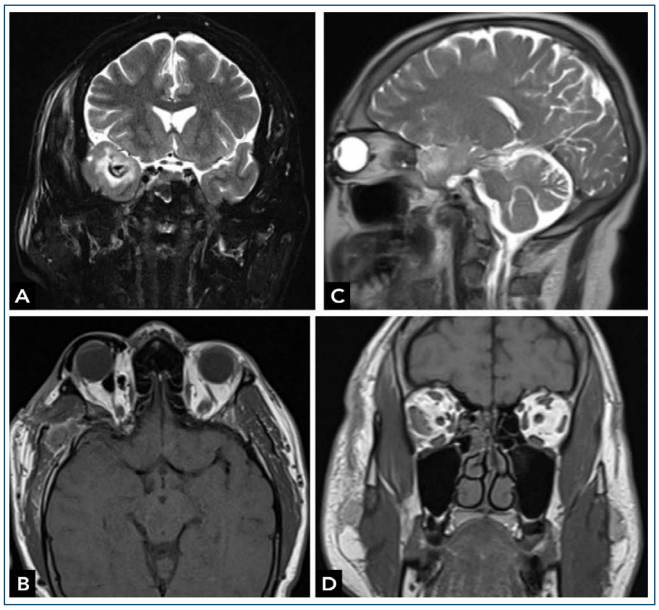

Figure 3. (A) Hemorrhagic parenchymal contusion located in the anterolateral aspect of the right temporal lobe, characterized by isosignal on T1 and heterogeneous signal on T2, measuring 2.9x2.1cm. (B) Edema and heterogeneity of the orbital and periorbital fat on the right, with foci of hyposignal on T1 and T2, probably gas content. (C) Discrete content with hyper/isosignal in T1 and hyposignal in T2 located in the posterior aspect of the right eyeball, suggesting hematic content, without typical morphology, but which may correspond to retinal detachment. Discrete rectification of the posterior aspect of the right eyeball, possibly related to orbital edema. (D) Volumetric increase and heterogeneity of the lateral rectus muscle of the right orbit.

ophthalmological follow-up. Seven months after the incident, the patient no longer returned for reassessment.

DISCUSSION

Transorbital intracranial penetrating injuries are relatively rare events and account for around 0.4% of all head injuries. Despite this, they account for 24% of penetrating head injuries in adults, and 45% in children.[1,2,5,6] Intraorbital foreign bodies are usually associated with injuries caused by high-velocity projectiles of more than 100m/s, such as firearms, explosions and car crashes.[2,4,7] The literature has described various objects capable of causing accidental penetrating injuries to the skull at low speeds of less than 100m/s, such as wooden sticks,[8,9] metal rods,[5] pencils,[10] paintbrushes,[11] knives.[12] Cases involving brake levers are rare.[13,14] After research, this study compiled all known cases of penetrating brake lever trauma in English to date (Table 1), dating from 2003 to 2021.[13-26] With the exception of three reports, which described injuries caused by the brake levers of quadricycles, walkers and motorcycles, all refer to accidents involving bicycle handbrakes. Ng et al.[16] presented a series of two cases.

The age range varied from 5 to 82 years old, although 10 (62.5%) of the 16 patients involved were between 5 and 10 years old. With regard to gender, 12 (75.0%) were male. The distribution of gender and age was in line with the literature.[1,2] Of the 16 cases, including this one, 13 involved fractures of the walls of the orbital cavity and it was observed that of these, the path was through the roof of the orbit in 6 (50.0%) patients, followed by the medial wall in 3 (18.75%) and the lateral wall in 2 (12.5%), with no fractures of the floor reported. In two patients, the foreign body only penetrated the interior of the orbit without an associated bone fracture and in one case the orbit was not affected.

The main trauma mechanism involved was an accidental fall while riding a bicycle. The higher prevalence of involvement of the orbital roof can be explained by the dynamics of the accident, where during the fall, as a defensive reflex, the individual extends their head backwards exposing the upper wall of the orbit.[1,4]

Turbin et al.[1] divided the surface of the orbit into four zones based on the patterns of low- speed cranio-orbital penetration by the foreign body. Zone 1 includes central, lateral or unspecified entry points in the upper eyelid or upper conjunctiva. Zone 2 includes the same entry points, but on the lower eyelid or lower conjunctiva. Zone 3 refers to all medial lesions of the orbit and is subdivided into a, b, and c, corresponding to the upper, middle and lower portions, respectively. Zone 4 encompasses lesions from Zones 1 and 2, excluding medial trajectories in all respects.

Several studies have shown that the orbital roof is the preferred entry route to the cranial cavity in low-velocity penetrating trauma, since in most cases the traumatic mechanism associated with this type of injury consists of an accidental fall, either towards or while holding a certain object.[1,2,4,27] The superior orbital fissure and the optic canal are also among the main transorbital paths.[8]

Due to the pyramidal shape of the orbit, penetrating objects are directed towards its apex, and the superior and inferior orbital fissures and optic canal serve as a gateway to the skull. Low-velocity penetrating injuries most often spare the eyeball because, due to its motility, the eye is often displaced to the side, allowing the object to penetrate the orbit, most of the time following a path that is almost perpendicular to its walls. This phenomenon sometimes does not apply to injuries involving high-velocity fragments, resulting in significant lacerations to the globe.[27,28]

Table 1. Cases involving penetrating cranio-orbital injuries caused by brake lever

Authors	Age, sex	Entry wound	Radiologic (tests and findings)	Trajectory	Operation notes	Outcome
Poroy et al.[13]	10, female	Right upper eyelid	CT; right greater wing of the sphenoid bone, nasal bone fracture, intracerebral and subarachnoid hemorrhage in the temporal lobe, medial rectus rupture, proptosis, orbital emphysema, pneumocephalus	Lateral wall of the right orbit	Lateral canthotomy, cantholysis, and superior and inferior septotomies were performed to prolapse the orbital fat and reduce the intraorbital pressure. The proximal and distal parts of the medial rectus muscle attached to each other. The conjunctiva, eyelid laceration, and lateral canthus were sutured and a temporary blepharorrhaphy was performed	No light perception, total optic atrophy developed, ptosis and eye movement restriction
Chattopadhyay et al.[14]	8, male	Left upper eyelid	CT; left orbital roof fracture	Left orbital roof	No surgical procedures were performed	Died
Sivalingam et al.[15]	35, female	Medial aspect of the left orbit	XR/CT; medial wall of the left orbit, nasal bone, left medial infraorbital rim and right maxillary sinus fractures. Foreign body obstructing the right coronoid process of the mandible	Medial wall of the left orbit	Transorbital extraction. The nasal bone fracture and the left medial infraorbital rim fracture were reduced and fixed with titanium plates	Complete recovery
Ng et al.[16]	5, male	Left upper eyelid	CT/MRI; left orbital roof fracture, orbital emphysema, pneumocephalus, and brain injury	Left orbital roof	Eyelid laceration was primarily repaired. Bifrontal craniotomy to repair the orbital encephalocele, with a pericranial dural graft and split-thickness calvarial bone graft for orbital roof reconstruction	0.5 mm ptosis OS and visual acuity was 20/25 OU
Ng et al.[16]	6, male	Left upper eyelid	CT; soft tissue swelling, proptosis, and hemorrhage in the left orbit	Intraorbital – no fracture in orbit walls	Orbital fat was reposited and the laceration primarily closed	Complete recovery
Ahmad et al.[17]	8, male	Left eye globe	CT; left orbital roof fracture, hemorrhagic tract running from the left supraorbital region, through the frontal lobe and basal ganglia into the midbrain, intraventricular hemorrhage	Left orbital roof	No surgical procedures were performed	Died
Agrawal et al.[18]	7, male	Below the right infraorbital margin	CT; right orbital roof fracture, hemorrhage in the suprasellar cistern, left internal capsule and basal ganglion, pneumocephalus	Right orbital roof	No surgical procedures were performed	Aphasia and right-sided weakness
Gopalakrishnan et al.[19]	9, male	Left cheek	CT; medial wall of the left orbit, ethmoid and sphenoid sinuses fractures, proptosis, foreign body penetrated through the right side of the cerebral peduncle reaching the tentorial hiatal edge, thick diffuse basal subarachnoid bleed and an established right posterior cerebral artery territory infarct	Medial wall of the left orbit	No surgical procedures were performed	Died
Nowroozzadeh[20]	25, male	Right lower eyelid	CT; two pieces of metallic intraorbital foreign bodies, one of which was embedded in the zygomatic bone, and the second one located in posterior superior orbit	Right eye globe; no fracture in orbit walls	Intraorbital extraction (2 foreign bodies), inferior rectus muscle disrupted was tied on area of Tenon's capsule, Conjunctiva and eyelids were sutured with proper materials	No light perception, complete ptosis and a frozen eye
Long et al.[21]	8, male	Anterior aspect of left ear	XR; no calvarial or facial fractures CT; extensive subcutaneous emphysema in the neck, left pterygoid plates fractures CTA; no evidence of arterial injury	Right temporo-mandibular joint	Manual extraction in operating room	Complete recovery
Huiszoon et al.[22]	45, female	Left eye globe	CT/MRI/MRA; left orbital roof fracture, multiple bone fragments extending into the brain near the circle of Willis, subarachnoid and intraventricular hemorrhage, pneumocephalus, obstructive hydrocephalus, extended intracerebral hemorrhage	Left orbital roof	Intracerebral hematoma evacuation and placement of intraventricular drain	Died
Crowson et al.[23]	82, female	Superomedial aspect of the right orbit	CT; right orbital roof fracture, herniation of the infraorbital fat and superior rectus muscles into the anterior cranial fossa, brain injury, globe and optic nerve intact CTA; no evidence of arterial injury	Right orbital roof	Frontal craniotomy via a coronal incision; craniotomy bone flap was reattached with titanium miniplates, repositioned the superior periorbital contents and the fractured orbital roof fragments; conjunctival peritomy; external ventricular drain was placed	Died
Sathish et al.[24]	55, male	Right upper eyelid	No imaging tests were performed	Right orbital roof	No surgical procedures were performed	Died
Sasidharan et al.[25]	8, male	Below the medial aspect of the left eyebrow	CT; small right frontotemporal parenchymal hematoma and a subdural hematoma along with infarct in the territory of the right middle cerebral artery The infarct and bleed caused mass effect and midline shift; CTA/MCA branch was occluded	Medial wall of the left orbit	Decompressive craniectomy and evacuation of hematoma	Complete recovery
Shihadeh et al.[26]	10, male	Left medial canthus	CT; left superior orbital wall fracture with a superiorly displaced fragment in the left frontal lobe, left frontal lobe herniation through the defect, and proptosis of the left globe with retrobulbar hematoma	Left orbital roof	Coronal incision allowed development of a pericranial flap between the temporal crests before the left frontal craniotomy	Some restrictions in left globe movement

CT: computed tomography; XR: X-ray; MRI: magnetic resonance imaging; OS: left eye; OU: both eyes; CTA: computed tomography angiography; MRA: magnetic resonance angiography; MCA: middle cerebral artery.

Turbin's Zones 1 and 3a[1] consistently penetrated through the roof of the orbit, and despite this, as a consequence, in Zone 1, they caused abscess formation, orbital encephalomenigocele, contusion and/or avulsion of bone fragments, while in Zone 3a, they damaged the temporal lobe, cavernous sinus, brainstem or cerebellum. In the present study, the same entry sites also showed different severity and complications.

The potential risk of neurological involvement, as well as the severity of the injury, from the orbital injury depends on the entry point, as well as the size, shape, energy, trajectory and angle and pattern of the fracture.[8,9,29]

Although entry wounds sometimes seem trivial, they do not predict the real extent of the injury. Immediate life-threatening intracranial complications include hemorrhage (subdural, subarachnoid, intraparenchymal, and/or intraventricular), edema causing mass effect, contusion, and/or cerebral laceration. The mortality rate among the patients in this study was 37.5%, and at least one of these alterations was visualized by imaging tests or autopsy. Pneumocephalus, cerebrospinal fluid fistula, decreased visual acuity or amaurosis, hemiparesis and aphasia have also been documented.[4,27,28] Among the mechanisms involved in visual loss are traumatic retinal detachment due to ocular contusion, direct or indirect traumatic optic neuropathy (TNO) and rupture of the orbit.[29,30] Kelishadi et al.[29] showed that the facial fracture pattern is another important variable that can predict visual impairment; injuries to the zygomatic-maxillary complex, frontal bone, nasal bone and orbital roof are associated with a higher incidence of visual deficits. In five patients in this study, some visual sequelae were observed. Three lost their sight completely on the affected side, two had a fracture of the lateral wall of the orbit and one had no associated fracture, and two had minor dysfunctions, both of whom had a fracture of the orbital roof, such as a slight reduction in visual acuity or restricted eye movement. The lateral wall is the most resistant wall of the orbit and, not just because of its proximity, the greater energy involved in its fracture is possibly linked to more serious complications of the eyeball, whether due to contusion, hemorrhage, or direct damage to the optic nerve.

Late complications involve infection, the most prevalent being meningitis and brain abscess, and vascular involvement, with the development of carotid-cavernous fistula and pseudoaneurysm.[27,28] Retained foreign bodies represent a greater infectious risk, especially organic materials such as wood fragments which provide a favorable environment for bacterial proliferation.[4,8] The occurrence of post-traumatic epilepsy is also an important event.[3]

Computed tomography is the first method of choice in the assessment of penetrating cranio-orbital trauma. Plain radiography is recommended when CT is available. Although CT can easily detect metallic foreign bodies, wood fragments can be difficult to visualize because their density resembles the brain parenchyma and soft tissues of the orbit. In cases involving non-metallic or organic objects, MRI evaluation is consistently superior.[1,3,9,12] Angiotomography or magnetic resonance angiography are indicated in suspected vascular lesions.[2]

The initial approach in any trauma scenario consists of following the protocols for advanced trauma life support. The admission Glasgow score may not be a good predictor of the real severity of the injuries, as mentioned by Huiszoon et al.,[22] whose patient had an initial score of 15 and during transfer developed signs suggestive of cerebral herniation and brain death.

Therefore, for all patients in whom there is the slightest suspicion of cerebral or vascular involvement, imaging and neurological assessment should be immediate. The penetrating object should be removed after proper clinical and imaging assessment and stabilization of the patient. Improper or premature removal, without adequate assessment and/or outside the operating room, can precede a fatal hemorrhage. Intracranial pressure should be monitored when an adequate neurological assessment cannot be carried out.[12]

A multidisciplinary surgical approach may be necessary due to the complexity of the trauma, including neurosurgery, ophthalmology, oral and maxillofacial surgery, and pediatrics. Craniotomy is preferable in suspected intracranial injury, and transorbital access is a viable and less invasive option.[8] Increased intracranial pressure due to hematoma or hemorrhage necessitates decompressive craniotomy.[31] Fracture reduction is necessary to prevent possible complications such as leptomeningeal cyst, epilepsy, cerebral herniation, and hemiparesis.[4,31] Simple extraction of the foreign body associated with occlusion and treatment of the entry wound may be sufficient in cases of no fractures or intracranial and ocular injury.[12] Antibiotic prophylaxis should be administered to prevent infection of the central nervous system.[12]

The prognosis in transorbital penetrating intracranial trauma depends not only on the extent and severity of intracranial and ocular involvement, but also on the early and appropriate diagnosis and management of complications.[3,4,7,12,24]

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