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MAJOR REVIEW

Patterns of Transorbital Intracranial Injury: A Review and Comparison of Occult and Non-Occult Cases

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Abstract. The authors present an illustrative case of occult transorbital penetrating intracranial injury in a child, and review the literature concerning patterns of low-velocity, non-projectile injury during the era of modern CT and MRI study. Review of the mechanism of injury and analysis of surface entry site of penetration in 38 cases suggests recurring patterns of injury in occult and non-occult cases. A classification system based on surface entry zone site is applied to these injuries. Knowledge of the classification system should increase clinical suspicion for this type of often occult, penetrating orbitocranial injury and direct appropriate investigation to provide earlier detection and diagnosis of the transorbital, intracranial penetration. (**Surv Ophthalmol 51**:449–460, 2006.

Key words. eyelid laceration • intracranial • occult • penetrating • transorbital

I. Introduction

Although transorbital cranio-cerebral injury may present dramatically, many injuries are subtle and may be initially occult. Seemingly innocuous injuries are especially dangerous, because they may result in a delay in presentation and failure to recognize the extent of the injury.

Penetrating orbital injuries historically constitute a significant threat to ocular and cerebral structures. Transorbital injuries represent up to 24% of penetrating head injuries in adults, and 45% in children.[23,55] Bard and Jarrett's 1964 review of intracranial complications from penetrating orbital injuries discusses cases of cerebral laceration, hematoma, pyogenic abscess, meningitis, encephalitis, cerebrospinal fluid leakage, traumatic pseudoaneurysm, carotid-cavernous fistula, subarachnoid hemorrhage, hemiplegia, coma, and even death.[3] Webster and colleagues found a 12.5% mortality rate from such injuries during World War II.[53] This figure is twice the mortality rate of penetrating cranial injuries entering the brain by other routes, and may be related to the exposure of intracranial contents to nonsterile sinus contaminant and subsequent development of infection.[53] Death may complicate modern non–war-related orbitocranial injury, as illustrated in a case report of intracranial extension from an orbital umbrella stab injury in 1983 by Seigel et al.[47]

The incidence of central nervous system damage from orbital injury is related to orbital bone anatomy as well as size, shape, and trajectory of the penetrating object. The orbit maintains a pyramidal shape with a quadrangular base formed by the

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orbital rim, converging triangular sides formed by the orbital walls, and an apex terminating at the superior and inferior orbital fissures and optic canal (SOF, IOF, OC). Suspended within this pyramid, the globe is fairly resilient to trauma due to its tough sclera and relative mobility within the surrounding bed of intraorbital fat.[9,34] Given this mobility, penetrating orbital injuries may not be accompanied by damage to the globe itself and can easily be overlooked. Likewise, the naturally occurring fissures can be traversed without damage to surrounding structures. Thus, the orbit provides direct access to the cranial cavity via the SOF, IOF, and OC even in the absence of significant bony fracture or globe injury.[3]

Low-velocity penetrations may be directed by the configuration of the converging orbital walls towards the apex and may exit unhindered via SOF, IOF, or OC toward the carotid artery, cavernous sinus, suprasellar cistern, temporal lobe, pons and brainstem.[1,2,34,35,45,47,56] Higher velocity injuries occurring at a perpendicular trajectory to the orbital wall usually result in direct bony fracture.[15,28,40,44] Vertically directed objects may pierce the roof of the orbit and cause frontal lobe damage.[7,12,18,26] Objects oriented horizontally in the axial plane may fracture the ethmoid bones or the posterior orbital wall.[5,13,28] Those driven with sufficient force along the 45° angle of the lateral wall may even cross the midline to damage contralateral structures.[9]

Trivial-appearing eyelid lacerations may camouflage occult deep penetrations and are frequently sutured without further investigation.[3,12,18] Neurologic signs and symptoms may initially be absent, and ocular damage minor. Low suspicion for intracranial extension leads to delay in diagnosis and may result in serious and potentially life threatening complications. The following discussion will examine mechanisms of both occult and non-occult transorbital intracranial injury from a review of recent literature spanning the time period of modern radiographic imaging to determine common patterns of injury. Analysis of recurring patterns will be used to predict intracranial extension from superficial wounds, thereby providing a guideline for more timely and accurate diagnosis and treatment of such cases.

II. Methods

A. SELECTION CRITERIA

The index case seen by the author (RET) and 56 previously published cases with orbitocranial injuries were reviewed. Articles were identified using an OVID Medline search by meshing key words *orbitocranial, injury, occult, transorbital.*[1–56] Cases typically spanned the time period from approximately 1980 to 2002 and were excluded if modern imaging techniques (computed tomography [CT]/magnetic resononace imaging [MRI]) were unavailable. All selected cases involved low-velocity, non-projectile transorbital injury. Twenty-one cases classified as occult (Table 1), and 16 classified as non-occult (Table 2) met inclusion criteria. In all occult cases, the presenting injury was deemed minimal and ophthalmologic evaluations were otherwise within normal limits, without significant abnormality in acuity, slit-lamp, or fundus examination. Exception to these criteria was made for three cases that presented with either commotio retinae or hyphema, but failed to illustrate signs of penetrating orbito-cranial injury.[39,46,48] Neurological findings were absent at time of presentation in all occult cases, with the exception of mild lethargy in three cases.[19,24,31] All individuals were alert, oriented, and without focal neurologic deficits. In all occult cases, patients were either discharged from the emergency room or underwent surgical closure of eyelid lacerations with or without hospitalization. Cases that failed to meet all of these criteria, but presented with similar injuries, were classified as non-occult.

B. EXCLUSION CRITERIA

Exclusion criteria included high-velocity projectile injury, assault-related knife injury, and injuries with severe ocular damage or globe rupture. Also excluded were injuries involving large penetrating foreign bodies greater than the diameter of the orbital rim, which often damage multiple structures and destroy anatomical landmarks. Any case in which proper modern imaging techniques (CT or MRI) were unavailable was also withdrawn from evaluation, such that all cases analyzed were considered to conform to modern standards of medical care.

C. METHODS

Previously published cases were reviewed with special attention to the type and mechanism of injury, as well as the location, size, and shape of the resulting periocular laceration. Associated ocular and systemic symptoms were noted, as were details of initial workup, management, and course. Delay in ultimate diagnosis was recorded, as were specific orbital entry site, site of intracranial penetration, and resulting intracranial complication in each case. When available, imaging modality, study type, and details of views obtained were included in the analysis. Appropriate informed consent was obtained from the index case.