Orbital Roof "Blow-in" Fracture: A Case Report and Review

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ABSTRACT

We report a relatively rare case of an essentially isolated orbital roof "blow-in" fracture in a pediatric patient. A 13-year-old male presented with headache and nausea following blunt facial trauma sustained during a skate boarding accident. CT head revealed soft tissue swelling and an abnormal bony density in the superior, posterior right orbital region. Follow-up CT orbits revealed a comminuted orbital roof "blow-in" fracture with involvement of the ethmoid air cells and two tiny foci of intracranial air. Expert consultation revealed normal ophthalmologic and neurologic examination; conservative management was recommended. The case report is followed by a brief overview of orbital fractures including pertinent radiographic considerations.

CASE REPORT

CASE REPORT

A 13-year-old male presented to his primary care physician with headache and nausea one day after sustaining right frontal and orbital blunt trauma during a skate boarding accident. The patient fell and impacted his face on concrete. The patient reported initially experiencing blurry vision that resolved; otherwise, a review of systems was negative except for the presenting complaints. Physical exam revealed facial swelling and ecchymosis in the right frontal and orbital region. Neurologic and ophthalmologic examinations were within normal limits. Vision and ocular movements were normal and intact. Unenhanced computed tomography (CT) of the head was obtained for further evaluation.

All imaging was obtained on a Siemens SOMATOM® Definition AS 128-slice CT scanner, Siemens Healthcare. Initial unenhanced CT head demonstrated right periorbital, preseptal, frontal, infraorbital, and zygomatic soft tissue swelling (Figure 1a), the subtle finding of abnormal bone density in the superior, posterior right orbital region (Figure 1b), and retrospectively a focus of intracranial air (Figure 1c). Further evaluation was performed with a CT of the orbits that demonstrated a comminuted right orbital roof "blow-in" fracture (Figure 2) with associated non-displaced linear fracture extension towards the supraorbital rim without supraorbital rim involvement (Figure 3a,c) and medial extension with involvement of the ethmoid air cells (Figure 3b). Orbital roof "blow-in" fracture fragment demonstrated direct contact with the superior rectus muscle (Figures 2 and 4); however, no involvement of the optic nerve was appreciated. Two tiny foci of intracranial air were more definitively identified (Figure 5). Overall, these findings were consistent with an essentially isolated orbital roof "blow-in" fracture with minimal involvement of the ethmoid air cells and two tiny foci of intracranial air.

Otolaryngology, ophthalmology, and neurosurgery consultations were obtained. These consultations revealed no changes in physical examination findings. Conservative, non-surgical management and close follow-up was recommended. Follow-up CT of the orbits performed five days after the trauma, and four days after initial imaging, revealed stable orbital roof "blow-in" fracture with resolution of intracranial air (Figure 6). One-week follow-up physical examination remained stable. Continued conservative management is planned contingent upon continued asymptomatic follow-up physical examinations and stable CT findings.

DISCUSSION

Craniofacial Trauma

Facial bone fracture is a common concern in the setting of significant facial trauma. With the advancement of multi-detector computed tomography, more detailed descriptions of facial trauma and associated morbidity has found its way into the medical literature. The characteristics of facial fractures differ between adult and pediatric populations. Approximately 5%-15% of facial fractures occur in children with increasing frequency associated with increasing age (1). The distribution of facial fracture locations and mechanisms of injury varies between the pediatric and adult patient populations (1-4). Epidemiologic differences between adult and pediatric patients is likely due to differences in the anatomy and physiology of each patient at their specific stage of facial development including the amount of paranasal sinus pneumatization and dentition (1). The differences in anatomy and physiology lead to the finding of more co-existent intracranial and non-head trauma in the pediatric craniofacial trauma patient compared to their adult counterpart (5). Unfortunately, the literature contains multiple, often conflicting, descriptions of the epidemiology of pediatric facial fractures. This is likely due to differences in study designs including limitation to only a single institution for data collection (1-5). There is a general consensus that the most common cause of craniofacial trauma is motor vehicle collision (1,5). Other causes differ in frequency based on the age of the patient and include falls, sports related injuries, and violence (1,5).

Orbital Roof Fractures, Epidemiology

An isolated orbital roof fracture is considered a rare finding; it is estimated that 1%-9% of facial bone fractures involve the orbital roof (2,3). In adults, orbital roof fractures are the least common orbital fracture and generally are encountered in males (approximately 90% male predominance) between 20 and 40 years of age after a motor vehicle collision (2,3). These fractures in adults commonly require surgical intervention (2). In children, orbital roof fractures are found near equally in males and females with a mean age between 3 and 5 years following a motor vehicle collision, fall, or assault depending on the patient's developmental stage (3). The frequency of pediatric orbital roof fractures is variable in the literature ranging from one of the least common facial fractures in the series (5) to the most common fracture in one study (2). Most children with orbital roof fractures have concomitant multi-system trauma with neurocranial injuries being the most common (3). In contrast to their adult counterparts, the average pediatric orbital roof fracture is minimally displaced or non-displaced and does not require surgical treatment (3).

Orbital Roof Fractures, Pathophysiology

There are several different configurations of orbital roof fractures including: non-displaced, isolated "blow-in," isolated "blow-out" (or "blow-up"), supraorbital rim involvement (without frontal sinus), frontal sinus involvement, and combination fracture (3). The common mechanism of injury for a superior orbital fracture is high-energy, blunt trauma to the orbit or forehead. The fracture is generally the result of direct extension of a force vector into the site of fracture, or due to a transient increase in orbital or intracranial pressure that results in fracture of the orbital roof.

The isolated orbital roof "blow-up" fracture, also known as "blow-out" fracture, is defined as superior displacement of the fracture fragment into the anterior cranial fossa without involvement of the supraorbital rim, with possible herniation of orbital contents outside of the orbital confines (3). The isolated "blow-up" fracture is thought to be the result of direct orbital blunt force with subsequent increased intraorbital pressure, hydraulic forces, and/or shear strain (3). The isolated "blow-in" fracture is defined as inferior displacement of the roof without involvement of the supraorbital rim or the frontal sinus, and is thought to be the result of increased intracranial pressure, a shift of the cranium, and/or a shift of the intracranial contents (3). The blow-in fracture effectively reduces the volume of the orbit and can cause associated intraorbital injuries including extraocular muscle entrapment and optic nerve injury. Although the terms "blow-in" and "blow-up" fractures refer to isolated injuries of the internal superior orbit, these injuries occur far more commonly in conjunction with supraorbital rim and frontal sinus involvement (3). When other craniofacial injuries are identified, it is thought that the mechanism of injury is direct transmission of force from displacement of the adjacent injury (3). Very rarely the orbital roof will fracture without displacement of fractures fragments, resulting in the non-displaced orbital roof fracture (3).

Radiological Considerations

In the setting of orbital roof fracture it is important to fully assess the extent of the fracture including any radiographically apparent concomitant abnormalities. As an isolated orbital roof fracture is a rare entity, it is important to search for any associated facial bone fractures. In any orbital fracture, it is important to assess the intraorbital soft tissues including the extraocular muscles, the optic nerve, and the globe (6,7). In the setting of an orbital roof "blow-in" fracture it is important to assess the fracture fragments and there relationship to the intraorbital structures. It is important to describe any encroachment upon or impingement of the extraocular muscles or the optic nerve. Impingement of extraocular muscles is a very common cause of decreased ocular motility (6). Visual function and globe integrity are important clinically. It is important to assess for common causes of visual impairment including globe rupture, retrobulbar hemorrhage, optic nerve edema, optic nerve impingement, detached retina, and intraorbital emphysema (6). Generally, radiological findings in conjunction with decreasing vision require immediate surgical intervention (7). Due to the close association of intracranial injuries with superior orbital fractures, it is important to assess for intracranial injuries including contusions, intracranial hemorrhage/hematoma, mass effect, and brain herniation. The surgeon should be alerted to the possibility of an associated dural injury, as this generally requires an intracranial surgical approach (7).

If there is clinical or radiographic concern for optic nerve involvement, magnetic resonance imaging (MRI) has been found to be superior to CT for assessment of intraorbital soft tissue injuries including injury of the optic nerve (6). However, MRI has many well known limitations including insensitivity to assessment of bone fragments and certain foreign materials including wood and certain types of glass (6). MRI is also limited by contraindications including the presence of a ferromagnetic foreign body in the vicinity of the orbit and accessibility issues in the setting of severe trauma (6). Ultrasound is not a commonly used modality in the setting of orbital trauma secondary to insensitivity in assessment of fractures, difficulty of soft tissue differentiation, relative difficulty in performing the procedure, and the operator-dependent nature of the examination (6). Given the accessibility and accuracy of evaluation of pertinent orbital structures, thin-slice multi-detector CT examination has become the radiological modality of choice, and generally the only required modality, for assessment of orbital fractures (1,6,7).

There are many suggested CT protocols in the medical literature for imaging facial/orbital fractures (1,6,8). The ideal protocol depends upon patient specific requirements and available imaging equipment (1,8). A thin-slice acquisition protocol (preferably 1 mm thickness or less) with multiplanar reformation including a minimum of coronal reformation is recommended (1,8). Some sources suggest that separate acquisition of axial and coronal images with subsequent multiplanar reformation is useful (8). However, a single acquisition in the axial plane followed by reformation is advantageous when trying to minimize radiation dose and when technically limited by severe, multi-system trauma (1,8). The addition of three-dimensional (3-D) volume rendering reconstruction can be useful for surgical planning and can potentially increase the sensitivity of the examination when used in conjunction with axial and multiplanar reformations (1,8). The protocol used in this case report included multidetector CT volumetric axial acquisition of 0.6 mm thickness per slice with subsequent multiplanar reformation of 2 mm thickness. This protocol was sufficient to adequately assess the findings while minimizing radiation dose.

Treatment

Orbital roof fractures are typically managed by otolaryngologists, ophthalmologists, neurosurgeons, plastic surgeons, and/or oral-maxillofacial surgeons depending on the individual case and associated imaging/clinical findings. Generally speaking, pediatric orbital roof fractures are less likely to require surgical repair than their adult counterpart (2,3). Currently there is no specific consensus on the treatment of orbital fractures in the pediatric population (9). Surgery is often performed if significant neurological, ophthalmologic, or aesthetic deficiency is clinically apparent or expected to eventually result from the injury and the surgical intervention is likely to improve clinical outcomes. In general, surgical intervention is utilized only to repair displaced and comminuted fractures that will likely cause functional disability, cosmetic deformity, or both (1). Pure "blow-in" fractures, "blow-out" fractures, and non-displaced fractures that are asymptomatic generally have minimal clinical consequences and can be managed conservatively without surgery (9). Fractures that extend beyond the orbital roof can generally be treated conservatively with diligent clinical and CT follow-up (9). Surgical intervention is not an entirely benign solution with postoperative complications including enophthalmos, extraocular muscle entrapment, infection, orbital volume discrepancy, and blindness (3,9).

Case Report Management

The patient in this case report presented with an essentially isolated right orbital roof "blow-in" fracture with a bony fragment contacting the superior rectus muscle. The injury also involved linear fracture extension toward the supraorbital rim without supraorbital rim involvement, minimal fracture involvement of the ethmoid sinus, and tiny foci of intracranial air on initial imaging. Physical examination revealed no significant visual, neurological, or cosmetic abnormalities. Therefore, the patient was managed conservatively without surgical intervention. The neurosurgical team was consulted due to the intracranial findings; however, conservative management and vigilant clinical and imaging follow-up was advised. The patient remained stable at one-week follow-up with resolution of intracranial air. Therefore, continued non-surgical, conservative management was pursued.

TEACHING POINT

In the setting of orbital roof "blow-in" fractures it is imperative to assess for associated facial bone fractures, intracranial abnormalities, causes of visual loss, and impingement of intraorbital structures including the extraocular muscles and optic nerve. These findings in conjunction with clinical symptomatology guide patient management and therefore must be clearly communicated to the clinician.

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FIGURES

Figure 1: 13-year-old male with comminuted right orbital roof "blow-in" fracture. Initial unenhanced CT head (obtained with a Siemens SOMATOM® Definition AS 128-slice CT scanner, Siemens Healthcare; axial acquisition of 0.6 mm thickness over the area scanned with subsequent reconstruction into 5 mm contiguous axial scans of 5 mm thickness; 120 kV; 425 mAs; Total Dose: 1.15 Gy) demonstrates (a) soft tissue swelling in the right infraorbital region anterior to the maxillary sinus and right zygomatic arch (arrow) on soft tissue window settings, (b) abnormal bone density (arrow) in the superior, posterior right orbit on brain window settings, and (c) retrospectively identified abnormal focus of intracranial air (arrow) in the anterior cranial fossa on brain window settings.

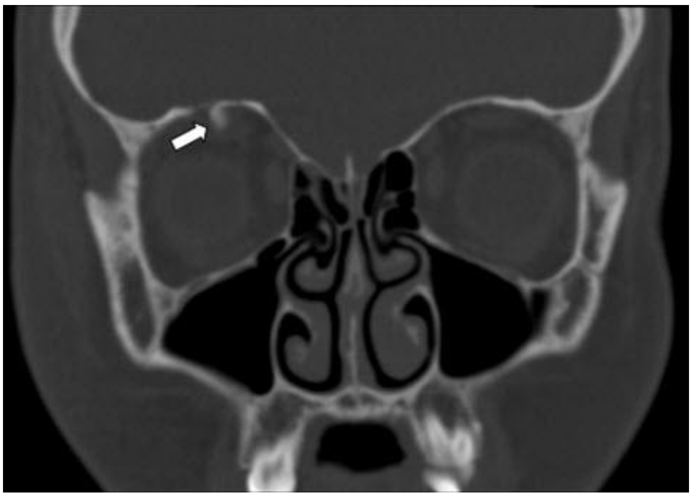

Figure 2 (left): 13-year-old male with comminuted right orbital roof "blow-in" fracture. Unenhanced CT orbits (obtained with a Siemens SOMATOM® Definition AS 128-slice CT scanner, Siemens Healthcare, using bone algorithm; axial acquisition of 0.6 mm thickness over the area scanned with subsequent reconstruction into 2 mm contiguous axial scans of 2 mm thickness reformatted in the coronal plane; bone window settings; 120 kV; 210 mAs; Total Dose: 354 mGy) demonstrates inferiorly displaced right orbital roof "blow-in" fracture with fracture fragment (arrow) contacting the superior rectus muscle.

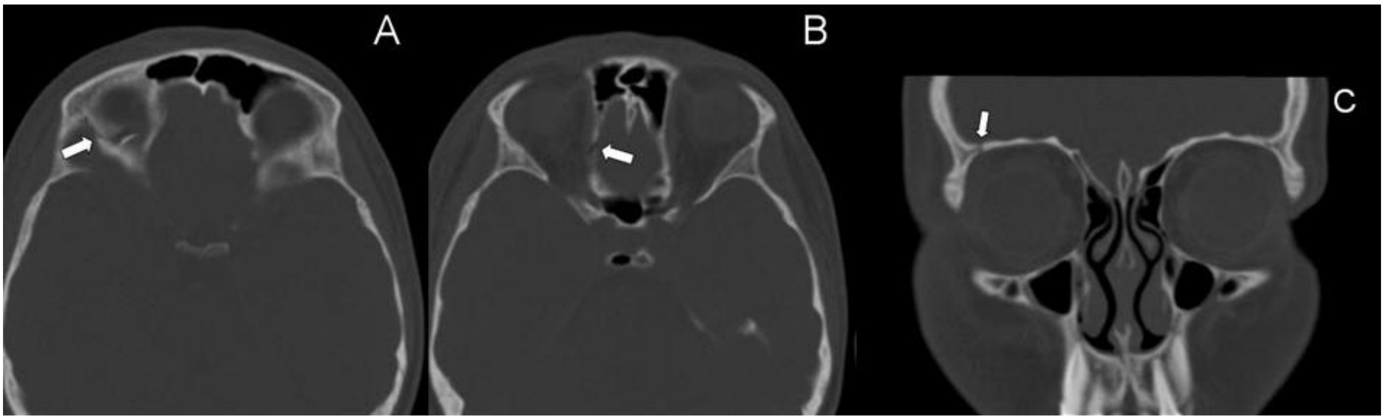

Figure 3: 13-year-old male with comminuted right orbital roof "blow-in" fracture. Unenhanced CT orbits (obtained with a Siemens SOMATOM® Definition AS 128-slice CT scanner, Siemens Healthcare, using bone algorithm; axial acquisition of 0.6 mm thickness over the area scanned with subsequent reconstruction into 2 mm contiguous axial scans of 2 mm thickness; 120 kV; 210 mAs; Total Dose: 354 mGy) axial images on bone window settings demonstrate (a) associated linear, non-displaced right orbital roof fracture towards the supraorbital rim (arrow) without involvement of the supraorbital rim and (b) associated medial linear fracture extension (arrow) to the ethmoid air cells. Coronal reformation (c) further demonstrates linear, non-displaced right orbital roof fracture (arrow) towards the supraorbital rim without involvement of the supraorbital rim.

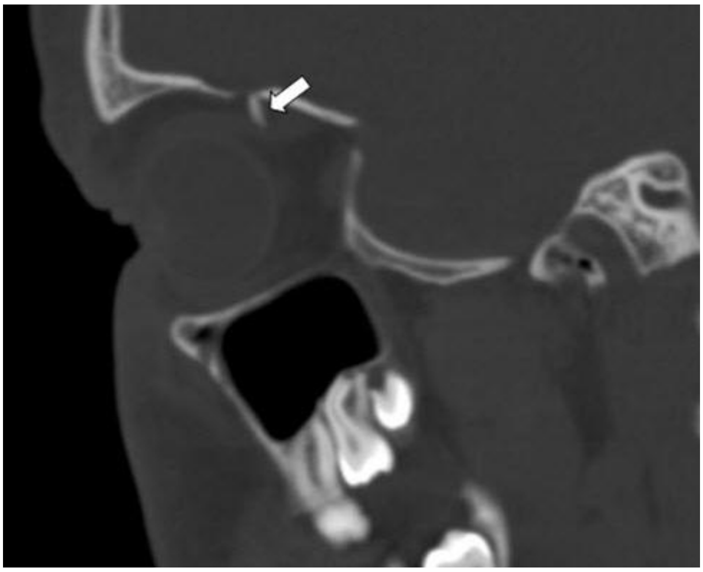

Figure 4: 13-year-old male with comminuted right orbital roof "blow-in" fracture. Unenhanced CT orbits (obtained with a Siemens SOMATOM® Definition AS 128-slice CT scanner, Siemens Healthcare, using bone algorithm; axial acquisition of 0.6 mm thickness over the area scanned with subsequent reconstruction into 2 mm contiguous axial scans of 2 mm thickness reformatted in the sagittal plane; bone window settings; 120 kV; 210 mAs; Total Dose: 354 mGy) demonstrates inferiorly displaced right orbital roof "blow-in" fracture with fracture fragment (arrow) contacting the superior rectus muscle.

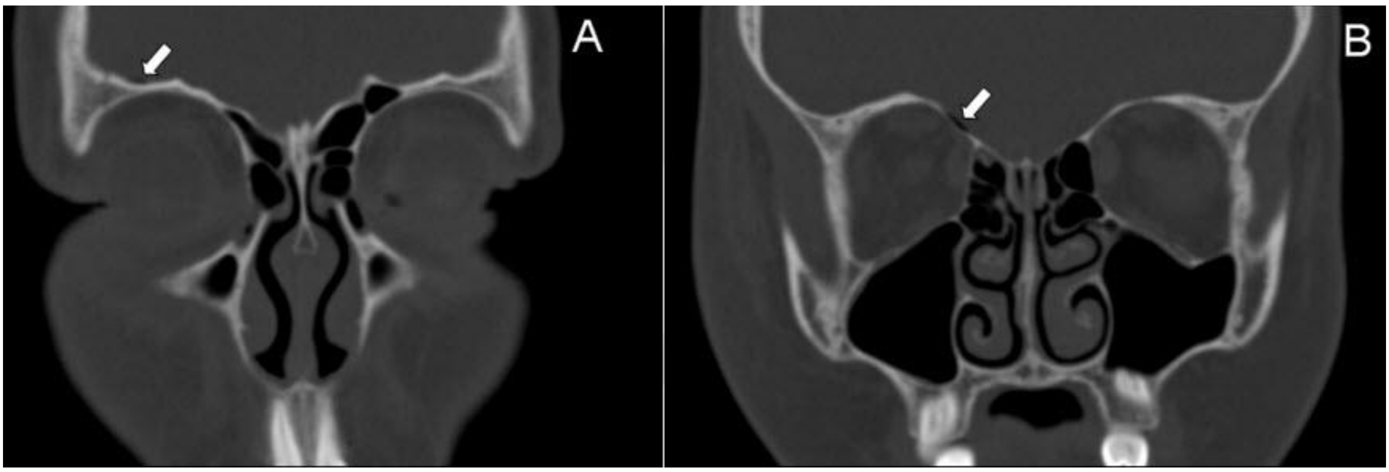

Figure 5: 13-year-old male with comminuted right orbital roof "blow-in" fracture. Unenhanced CT orbits (obtained with a Siemens SOMATOM® Definition AS 128-slice CT scanner, Siemens Healthcare, using bone algorithm; axial acquisition of 0.6 mm thickness over the area scanned with subsequent reconstruction into 2 mm contiguous axial scans of 2 mm thickness reformatted in the coronal plane; bone window settings; 120 kV; 210 mAs; Total Dose: 354 mGy) demonstrates (a, b) 2 foci of intracranial air (arrows) in the anterior cranial fossa.

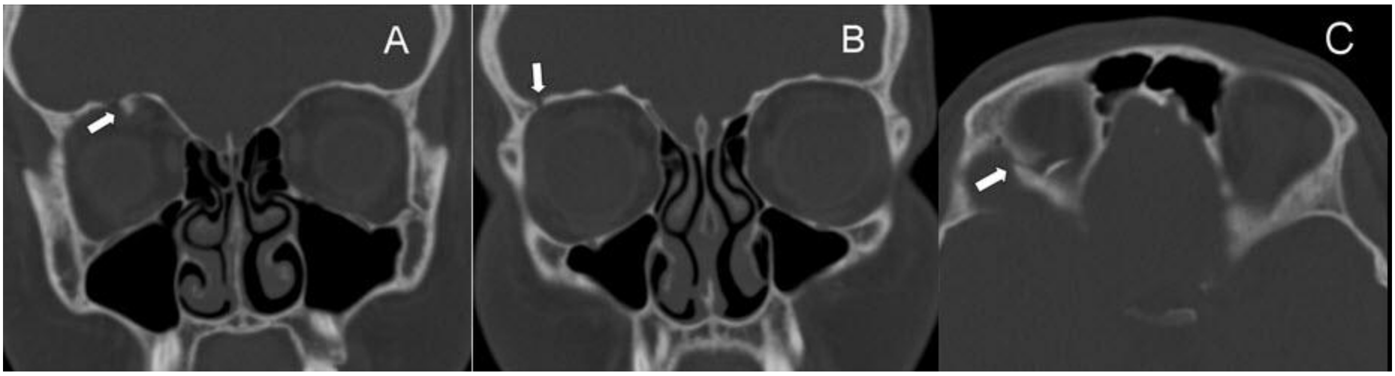

Figure 6: 13-year-old male with comminuted right orbital roof "blow-in" fracture. Four day follow-up unenhanced CT orbits (obtained with a Siemens SOMATOM® Definition AS 128-slice CT scanner, Siemens Healthcare, using bone algorithm; axial acquisition of 0.6 mm thickness over the area scanned with subsequent reconstruction into 2 mm contiguous axial scans of 2 mm thickness; bone window settings; 120 kV; 210 mAs; Total Dose: 330 mGy) coronal reformation images demonstrate (a) stable right orbital roof "blow-in" fracture with fragment involvement of the superior rectus muscle (arrow) and (b) stable extension of orbital roof fracture without supraorbital rim involvement (arrow). Axial image demonstrates (c) stable extension of right orbital roof fracture (arrow).

ABBREVIATIONS

CT = Computed tomography
MRI = Magnetic resonance imaging
mm = Millimeter

KEYWORDS

Superior orbital fracture, orbital roof "blow-in" fracture, computed tomography, CT head, CT orbits

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