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IMAGING

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CE

Orbital Floor Fractures

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ABSTRACT
The orbital bones are thin and exposed, making the orbital walls vulnerable to fractures. The floor of the orbit is the weakest portion of this 4-sided pyramid structure. Blunt force trauma is the primary mechanism of injury in young men between the ages of 18 and 30 years. Computerized tomography is the primary imaging technique to diagnose orbital fractures. Conservative versus surgical management is determined by maxillofacial and ophthalmology specialists. **Key words:** blowout fracture, globe injury, globus injury, hypoglobus, inferior rectus entrapment, ocular injury, orbital floor, trapdoor fracture

THE ORBITAL APERTURE (eye socket) comprises four walls that resemble a four-sided pyramid structure. The four walls include the roof, floor, and medial and lateral walls (Kwon et al., 2016). There are seven bones that encase the orbit. These seven bones include the frontal, maxilla, zygomatic, sphenoid, palatine, ethmoid, and lacrimal bones (see Figure 1; Hansen, 2014). Although the rim of the orbit is relatively strong, the walls of the orbit are vulnerable to fractures because the bones are thin and in an exposed position, with the orbital floor being the weakest portion of the orbit (Gosau et al., 2011). The paranasal sinuses surround the orbit, leaving it unsupported and susceptible to a blowout fracture ("Blowout Fracture," 2009). An orbital blowout fracture is a traumatic deformity of the orbital floor or medial wall, typically resulting from the impact of a blunt object.

An orbital fracture is a break in the continuity of the bone that houses the eye. When the fracture is isolated to the medial wall and/or the orbital floor, with the break being in the zygomatic-maxillary bone, it is defined as an orbital floor fracture or "blowout fracture". When the orbital rim and orbital walls are involved in the fracture, it is identified as an impure orbital wall fracture, whereas when the orbital rim is not involved, the fracture is identified as a pure orbital blowout fracture. The incidence of impure to pure orbital

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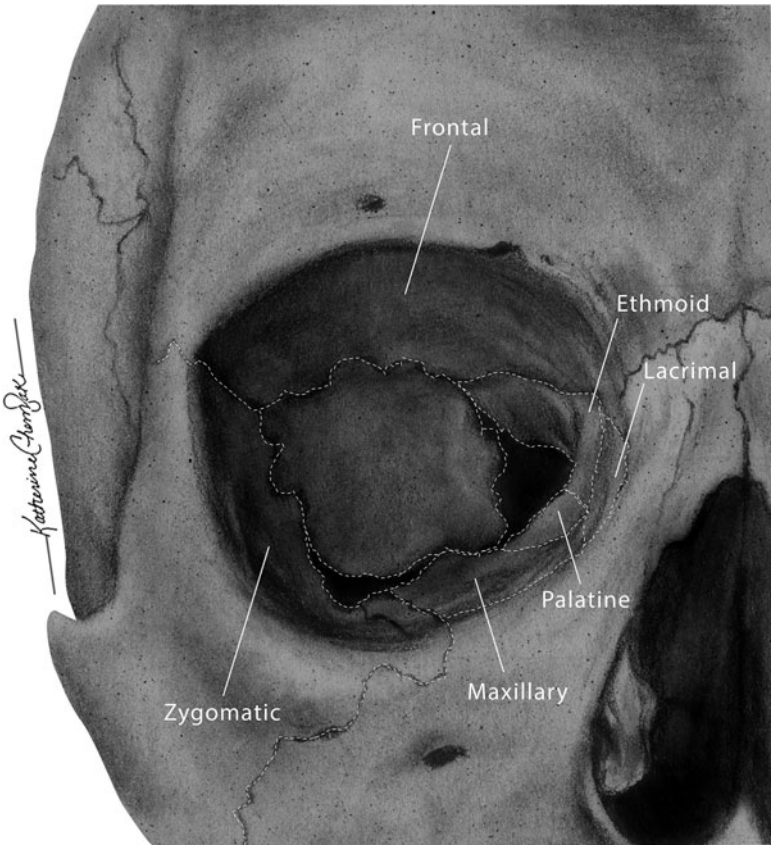

Figure 1. Orbital bones. Illustration is original artwork by Katherine Chemsak.

floor fractures is 3:1 (Gulati, Gupta, & Singh, 2011).

There are six extraocular muscles that control the movement of the eye. These muscles include the superior rectus, superior oblique, medial rectus, lateral rectus, inferior rectus, and inferior oblique muscles (see Figure 2). When an orbital floor fracture or "trapdoor" fracture (see Figure 3) occurs, the inferior rectus muscle can easily become trapped in the fracture fragments, thus limiting the eye movement to the upward position.

There are also differences in human anatomy pre- and postpuberty. Before the onset of puberty, most of the bones of the orbital floor are immature and lie over a small maxillary sinus that is more likely to fracture in a small linear pattern, whereas postpuberty, the maxillary sinus is enlarged, causing the orbital floor to become thinner and more likely to shatter with blunt force trauma (Egbert, May, Kersten, & Kulwin, 2000).

MECHANISM OF INJURY

Blunt force facial trauma from an object larger than the orbital aperture is the primary risk factor for an orbital floor fracture. Frequent causes of blunt force facial trauma include a direct blow to the face while participating in sports, especially those that include ocular trauma from a ball or body part of another participant, physical assault such as a fist to the face, and motor vehicle/motorcycle crashes (Gulati et al., 2011).

There are two theories as to the mechanism of injury of orbital floor fractures. The first is called the "hydraulic theory," which

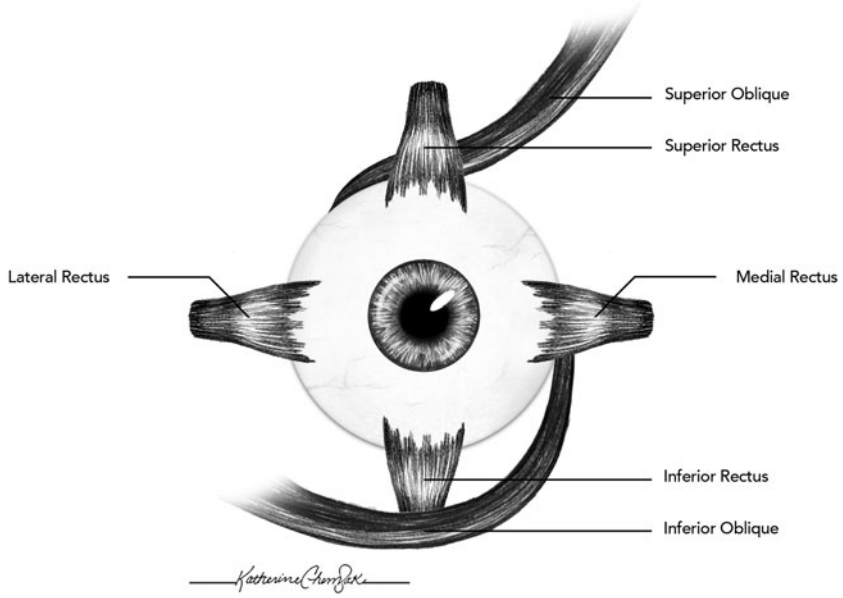

Figure 2. Extraocular muscles of the eye. Illustration is original artwork by Katherine Chemsak.

relates that direct blunt trauma to the soft tissue (eyeball) of the orbit causes the eye to be pushed posteriorly, increasing intraocular pressure and producing the fracture. The second theory is called the "buckling theory," which relates that the direct blunt force to the infraorbital rim causes buckling and consequently the orbital floor fracture (Mehanna, Mehanna, & Cronin, 2009).

In addition, because pediatric patients have more elasticity of the bone, a trapdoor fracture or "white-eyed blowout" is possible. A trapdoor fracture is defined as a small orbital floor fracture that entraps the inferior orbital

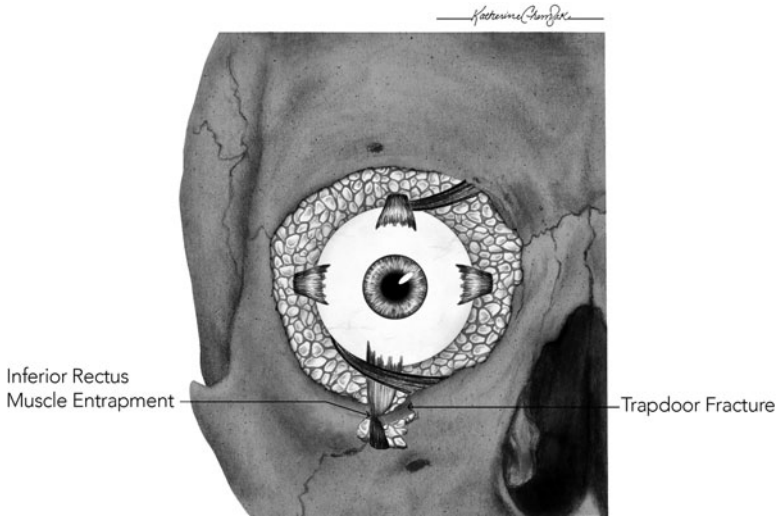

Figure 3. Trapdoor fracture of the orbital floor. Illustration is original artwork by Katherine Chemsak.

contents (inferior rectus muscle) and their fascia within the fracture because the elastic bones of the pediatric patient restore back to their original place (McInnes & Burnstine, 2010). A white-eyed orbital blowout fracture has minimal signs of external trauma. These can lead to increased complications if not identified early.

RISK FACTORS/PREDISPOSING FACTORS

Clinical trends indicate that individuals at greatest risk for a blowout fracture tend to be men between the ages of 18 and 30 years ("Blowout Fracture," 2009). Primarily, it is this population that engages in more dangerous and hazardous behaviors that lead to blunt trauma to the face (Layton, 2014). The predisposing factors of males in this age group influence both the type of behaviors and lifestyle choices that are characteristically associated with the probability of such adverse events. In addition, the pediatric population is at increased risk for trapdoor fractures.

INCIDENCE

There are differences in documentation as to the incidence of occurrence of ocular injuries, although it has been well documented that ocular emergencies are noteworthy. Thiagarajan (2014) identified that 70% of patients who present with maxillofacial trauma experience an orbital fracture. In addition, Kwon et al. (2016) identified that 22%–47% of all orbital fractures are blowout fractures. In addition, the *American Journal of Emergency Medicine* documents the prevalence of eye injury in the general population at 14.4%, with 2.4 million ocular injuries happening in the United States every year (Cheung et al., 2014).

CLINICAL FEATURES

Initial Assessment

In the emergency setting, it is important to initially evaluate the patient with facial trauma for life-threatening injuries. The patency of the airway and the patient's hemodynamic status, cervical spine, and neurological status must be assessed before moving on to the assessment of the orbit. Once the patient has been determined to be neurologically and hemodynamically stable, the patient can be assessed for ocular trauma (Deangelis, Barrowman, Harrod, & Nastri, 2014). Any person presenting with orbital trauma must be examined to rule out ocular injury and orbital fracture (Petrigliano & Williams, 2003). In this situation, rapid assessment takes priority over patient history (Deangelis et al., 2014). When assessing a patient with a potential orbital fracture, rapid clinical assessment is important to identify any vision-threatening injuries that may require immediate specialist consult.

VISION-THREATENING INJURIES

When assessing a patient with an ocular injury, it is important to determine which structure(s) is involved. It is important to determine whether the injury involves only the orbit or whether the injury may involve the bulb, optic nerve, retina, or other ophthalmic structures. Ocular injury may be indicated by a patient report of monocular diplopia or the objective findings of corneal laceration and/or hyphema (Petrigliano & Williams, 2003). Orbital/retrobulbar hemorrhage may be present if findings include the subjective report of eye pain or the physical findings of proptosis, central retinal artery pulsations (Petrigliano & Williams, 2003), or exophthalmos (Thiagarajan, 2014). Patient report of bilateral visual acuity changes may indicate injury to the optic nerve (Petrigliano & Williams, 2003). Pupillary muscle dysfunction associated with subjective report of visual disturbance may indicate injury to the optic nerve and requires immediate referral for optic nerve decompression (Thiagarajan, 2014). Ocular injury, orbital and retrobulbar hemorrhage, optic nerve damage, retinal injuries, and penetrating eye trauma all constitute ophthalmic emergencies that may threaten vision and require immediate consult

with ophthalmology and/or maxillofacial surgery (Deangelis et al., 2014; Petrigliano & Williams, 2003).

HISTORY AND PHYSICAL ASSESSMENT

Once the patient is stabilized and immediate vision-threatening injury has been ruled out, a more thorough patient history and assessment for orbital fracture can be undertaken. The history should focus on mechanism of injury and the patient's current symptoms. Mechanism of injury is important, as the type of object that may have struck the orbit will affect the type of injury that may occur to the globe or orbit (Petrigliano & Williams, 2003). The patient should be questioned about loss of consciousness at the time of the injury, as well as the development of monocular diplopia, binocular diplopia, vision loss, or eye pain subsequent to the injury (Deangelis et al., 2014; Petrigliano & Williams, 2003). Monocular diplopia could be a symptom of retinal detachment, lens dislocation, or presence of a foreign body (Deangelis et al., 2014). Binocular diplopia may indicate edema (Deangelis et al., 2014) or optic nerve involvement. Red flag symptoms include severe eye pain, loss of vision, or diplopia. These symptoms indicate a threat to vision and must be addressed promptly. Assessment of visual acuity with use of the Snellen chart has been found to be important to prognosis. If the patient is unable to read the Snellen chart, other methods such as the Rosenbaum chart (hand-held vision card), reading newsprint, counting fingers, perceiving hand motion, or light perception should be utilized as alternatives. The orbit and the bulb should be inspected for the most common signs of orbital fracture such as periorbital ecchymosis/hematoma, subconjunctival hemorrhage, and enopthalmus (Gulati et al., 2011). Position of the globe should be noted, as enopthalmus/hypoglobus may indicate orbital fracture whereas exophthalmos/proptosis may indicate retrobulbar hemorrhage, which is an ophthalmic emergency.

Restriction to the extraocular movements (EOMs) should be noted, as this could indicate papillary muscle entrapment/herniation within an orbital fracture, most frequently the orbital floor (Petrigliano & Williams, 2003). A thorough neurological assessment of the face must be undertaken to assess for nerve palsies or numbness of the cheek and lateral nose, which may indicate damage to the infraorbital nerve, which runs through the floor of the orbit (Thiagarajan, 2014). Physical findings with high correlation to orbital blowout fracture include diplopia, limitation of the EOMs to the lateral and upward positions, and enopthalmus/hypoglobus due to entrapment of orbital tissue (Deangelis et al., 2014; Petrigliano & Williams, 2003; Thiagarajan, 2014), as well as numbness of the distribution of the infraorbital nerve. Nonspecific signs of orbital fracture may be subconjunctival hemorrhage, edema of the eyelid, and ecchymosis at the site of trauma. The absence of any of the signs of orbital fracture does not rule out orbital fracture; further diagnostic testing may be required (Petrigliano & Williams, 2003).

DIAGNOSTIC IMAGING

Computerized tomography (CT) without contrast is the imaging technique of choice for orbital injuries, as it allows for better visualization of soft tissues (Petrigliano & Williams, 2003) and the bony structures of the orbit. The presence of any of the physical findings with high or nonspecific correlation to orbital fracture is an indication for the CT scan (Deangelis et al., 2014). The use of the coronal and axial CT scans has been shown to be the most accurate in the diagnosis of orbital floor fractures (see Figure 4; Freund, Hähnel, & Sartor, 2002; Petrigliano & Williams, 2003), and CT has been found to be superior to magnetic resonance imaging (MRI) in the evaluation of trauma to the orbit (Freund et al., 2002). Although the orbital floor fracture may not always be visible on imaging, the herniation of orbital contents confirms a fracture and may be revealed as the teardrop sign on the CT scan. Along with the subjective report of diplopia by the patient, herniation of orbital contents is an indication for surgical repair of

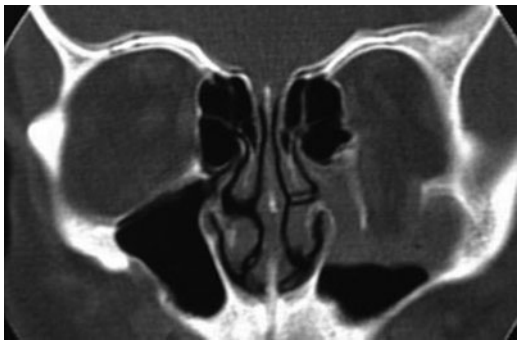

Figure 4. Coronal computed tomographic scan of orbits demonstrating loss of orbital floor on the left in contrast to the normal orbital floor on the right. Reprinted with permission from Medscape.

the fracture. Retrobulbar hemorrhage found on the CT scan is an emergency, and specialist consult should be requested for immediate intervention (Deangelis et al., 2014). Some studies have shown MRI to be superior to CT when evaluating for soft-tissue herniation. In this case, MRI could serve as an adjunct to CT if the determination of soft-tissue entrapment is in question following the CT scan (Freund et al., 2002). The use of ultrasonography for the diagnosis of orbital floor fracture is less sensitive than CT and may need to be used in situations where a fracture is suspected but CT evaluation is either not possible or not practical (Petrigliano & Williams, 2003). The use of plain radiographs to diagnose orbital fractures is not recommended (Petrigliano & Williams, 2003).

MANAGEMENT OF THE PATIENT WITH AN ACUTE ORBITAL FLOOR FRACTURE

Emergency Management

Emergency management of the patient with an acute orbital fracture must initially be focused on identifying the signs and symptoms that put the patient at most risk for loss of vision or other permanent damage related to the fracture. The management should be individualized and based upon the entirety of the patient history, symptoms, physical examination findings, and the results of imaging studies (Petrigliano & Williams, 2003). Patients whose injury has no imminent threat to vision and the absence of enopthalmus or signs of papillary muscle entrapment (Thiagarajan, 2014) are usually candidates for conservative treatment. The literature does reveal some disagreement among specialists between the use of conservative treatment and early surgical intervention for the treatment of a patient with an orbital floor fracture. Early surgical treatment was the standard of care until the 1970s when conservative, nonsurgical treatment revealed satisfactory outcomes (Petrigliano & Williams, 2003). If immediate referral is not indicated, the medical provider should monitor the patient in the emergency setting for a few hours for delayed hematoma (Deangelis et al., 2014). During that time, the medical provider can treat the patient for pain and provide cool compresses to the injured area to decrease swelling. Oral antibiotics may also be ordered to decrease the risk of infection that can occur, as the orbit may be exposed to bacteria from the paranasal sinuses when fracture is present. Decongestants and steroids may be ordered to help reduce nasal congestion and swelling of soft tissue, respectively (Deangelis et al., 2014; Petrigliano & Williams, 2003). When a vision-threatening injury is excluded, suspected or confirmed blowout fracture must be discussed with the maxillofacial surgeon on call. The surgeon can determine whether the patient needs to be seen in consult immediately or he or she may recommend follow-up within a day or two of the injury.

Surgical Management

Immediate indication for surgery includes retrobulbar hematoma with globe or optic nerve compression, which is associated with vision impairment (Gosau et al., 2011). Surgical management is recommended for those patients presenting with one or more of the following: inferior rectus muscle entrapment (Gosau et al., 2011; Petrigliano & Williams, 2003), fractures involving more than 50% of the floor of the orbit, enopthalmus, or other

globe displacement greater than 2 mm (Gosau et al., 2011; Gulati et al., 2011; Petrigliano & Williams, 2003), and hypoglobus or diplopia that do not resolve in 2 weeks (Gosau et al., 2011; Gulati et al., 2011). As mentioned previously, the maxillofacial surgeon or other appropriate surgeon as identified by hospital policy needs to be consulted for suspected or confirmed orbital fractures in the emergency setting such that determinations can be made regarding the need for immediate surgical intervention.

Objectives of surgery are to release entrapped soft tissue and restore anatomy (Gosau et al., 2011; Thiagarajan, 2014). Surgical delay can lead to formation of fibrous tissue and contracture of any prolapsed tissue. This can lead to poor surgical outcomes and permanent damage. Diplopia alone, following an orbital floor fracture, is not an indication for early surgical repair, as the diplopia often resolves once the initial inflammation and swelling have resolved (Petrigliano & Williams, 2003). Persistent diplopia, however, following an orbital floor fracture may be an indication for surgical intervention (Petrigliano & Williams, 2003).

FOLLOW-UP AND COMPLICATIONS

Follow-up after orbital floor fracture must include assessment for visual acuity, persistent diplopia, persistent pain, limitation of EOMs, and enopthalmus (Petrigliano & Williams, 2003). Pain, diplopia, and limitation of EOMs could indicate herniation and entrapment of periocular fat and extraocular muscles and are a cause for surgical intervention. If not surgically repaired, necrosis of this tissue can occur (Petrigliano & Williams, 2003) and with late repair, surgery may not be effective for relief of symptoms (Petrigliano & Williams, 2003). Complications of an orbital floor fracture can be minor and include bruising and temporary diplopia. More severe complications can include problems such as retrobulbar hematoma (Gosau et al., 2011), traumatic optic neuropathy, which can lead to unilateral vision loss (Ong, Qatarneh, Ford, Lingam, & Lee, 2014), and heart block (Layton, 2014) secondary to stimulation of the oculocardiac reflex. Occulocardiac reflex can cause symptoms such as nausea, vomiting, vertigo, and bradycardia and occurs most often in posterior orbital floor fractures (Worthington, 2010).

CONCLUSION

Patient assessment for orbital floor fractures includes mechanism of injury, symptoms, and physical findings. Red flag symptoms such as severe eye pain, loss of vision, and diplopia require immediate ophthalmological consultation because they represent a threat to loss of vision. Physical findings such as enopthalmus and limitation of EOM/range of motion in the upward and lateral positions indicate a high correlation of orbital blowout fracture. Computed tomography has been demonstrated to be the most accurate for diagnosing orbital floor fractures. Definitive management will be determined by ophthalmology and maxillofacial specialists.

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