Advances in the Reconstruction of Orbital Fractures

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KEYWORDS

• Orbit fracture • Navigation • Mirror image • Computer • Preoperative planning • Endoscopic • Outcomes

KEY POINTS

- Repair of orbital fractures should be carried out to restore premorbid orbital contours with the greatest possible precision.
- Reconstruction should be performed after resolution of edema from the injury.
- Exophthalmometry is important in the decision to operate, intraoperative measurements, and postoperative outcome evaluation.
- Orbital endoscopy improves ability to visualize the entire extent of the fracture with increased illumination and magnification while reducing retraction of orbital contents.
- Surgical navigation with mirror-image overlay guidance provides a template for reconstruction when normal anatomic landmarks have been damaged and, when used with an endoscopic technique, leads to significant improvement in multiple surgical outcome metrics.

INTRODUCTION

Orbital reconstruction is one of the most challenging tasks of the surgeon who treats craniofacial trauma. Suboptimal outcomes may lead to debilitating morbidity with significant emotional, functional, and occupational deficits. These deficits can include diminished visual acuity, diplopia, loss of depth perception, chronic or severe pain, as well as depression and impaired mobility. Given that the orbital region is perceived as the greatest determinant of beauty, failure to restore preoperative appearance in this highly visible and difficult-to-camouflage location often creates significant emotional distress.

In addition to the high functional and emotional impact of these injuries, repair of orbital fractures is challenging because of the complexity and variability of the anatomy. Reconstructive landmarks are often obscured by the trauma; the contralateral structure cannot be exposed for comparison; and the orbital contents are often markedly displaced

Disclosure Statement: S.E. Bevans is a member of the United States Army. The views expressed here are those of the authors and do not reflect the official policy or position of the Department of the Army, Department of Defense, or the U.S. Government. Additionally, reference herein to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government. K.S. Moe is the Founder of SPI Surgical, Inc but has no conflicts of interest.

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Facial Plast Surg Clin N Am 25 (2017) 513–535
http://dx.doi.org/10.1016/j.fsc.2017.06.014

into adjacent anatomic regions. Furthermore, even minor inaccuracy in repair of the fracture can cause functional and esthetic disturbances postoperatively, as can the edges of a fracture or entrapment of orbital contents under the implant.

Orbital fractures are frequent injuries, with a nationwide incidence exceeding more than 100,000 patients per year in the United States.[1] The cause of orbital injuries is shifting in the United States and other developed countries; motor vehicle accidents have overtaken assault as the most common cause. An increasing rate of falls make this the third most common cause of orbital fracture, followed by sports and industrial injuries. In all reports, the most frequently injured subgroup is men between 21 and 35 years of age; however, injuries to women, adolescents, and the elderly are also common.[2,3] Domestic violence remains an important cause of midface or isolated orbital injury among women.

Brain injury occurs in 38% to 61% of patients with orbital injuries, and the incidence of multiple facial fractures and brain injury increases with higher-impact injuries.[4] The rate of ocular injury ranges from 14% to 40% of patients with facial fractures, highlighting the need for a low threshold for ophthalmologic evaluation.[5] Most fractured orbits are minimal, however, and do not require repair even if other coincident facial fractures require surgical intervention.[2,3,5,6]

A recent biomechanical study validated historical observations regarding the amount of force required to fracture orbital walls, finding only 2 N-m of force was required to fracture the orbital floor relative to more than 4 N-m of force required to fracture the medial orbital wall.[7] Several theories of force transfer have been proposed. The hydraulic theory suggests that force is transferred to the orbital contents, increasing orbital pressure, and, thus, exerting hydraulic pressure on the orbital walls causing a fracture. Alternatively, the buckling theory describes transmission of force from direct contact with the orbital rim, creating a shockwave whereby the weakest area bone succumbs to forces of deformation. Less commonly, direct contact only with the globe results in retropulsion into an orbital wall causing a fracture.[8–10]

Despite the relative frequency with which surgeons will be asked to evaluate and manage patients with orbital fractures, there remains a great deal of controversy about patient selection for operative management and how to achieve optimal results. Specifically, debate remains about how to determine which patients will need operative intervention, timing of surgery, preoperative and postoperative antibiotic use, and a myriad of intraoperative techniques (eg, surgical approach, material used for reconstruction, intraoperative implant positioning confirmation, and so forth). In this article, the authors describe the technique they have developed and currently use at the University of Washington Harborview Medical Center (a level I trauma service) with a summary of recent literature applicable to these controversial topics.

ORBITAL ANATOMY

The orbit is formed by the confluence of 7 bones (**Figs. 1** and **2**). Conceptually, these are categorized into an orbital *exoskeleton* and *endoskeleton*. The exoskeleton is created by the external portions of the maxillary and frontal and zygomatic bones, which form the orbital rims. The endoskeleton, the internal walls of the orbit, are created by the intraorbital portions of these bones with the addition of the lacrimal, palatine, and sphenoid bones.

At the junction of the ethmoid and frontal bones are the ethmoid arteries. It is typically taught that there are 2 vessels, the anterior ethmoid artery located 24 mm posterior to the anterior lacrimal crest and the posterior branch 12 mm further posterior, 6 mm from the optic canal. There is actually significant variability in the number and location of branches of ethmoid arterial system, most often with 3 arteries in unpredictable positions.[11] At the junction of the lateral orbital wall with the orbital floor is the zygomaticofacial neurovascular bundle anteriorly and the zygomaticotemporal neurovascular bundle posteriorly. The superior orbital fissure and adjacent bone contain both sensory and motor nerves as well as the mechanical anchors important to extraocular motion, whereas the inferior orbital fissure contains only minor sensory nerves, which can be sacrificed without notable deficit (see **Fig. 1**).

The orbital floor is the shortest wall of the orbit and comprises the roof of the maxillary sinus. It is 35 to 40 mm in anterior/posterior length and variably concave, with a depression just behind the orbital rim and an upward slope to the orbital apex. The inferior rectus muscle runs in close proximity to the orbital floor for most of its length. The muscle belly is normally oval in appearance on coronal imaging but can become rounded when damaged or inflamed (a sign to evaluate on imaging). Because of the close approximation to the orbital floor, small spicules of bone are often in close approximation to the inferior rectus on coronal imaging.[12] The total orbital volume for an adult is approximately 30 to 35 mL, approximately 7 mL of which is occupied by the globe.[13]