

Orbital trauma: from anatomy to imaging patterns – a pictorial review

B. Dobrovăț¹, R. Popescu¹, A. Nemtoi¹, O. Ladunca¹, D. Haba²

¹PhD student in Radiology, “Gr.T. Popa” UMPH, Iasi

²Radiology Clinic, “Prof. dr. N. Oblu” Clinic and Emergency Hospital Iasi

Abstract

Objective: In assessing the patients with orbital trauma, a basic knowledge of anatomy of this region is necessary to determine the gravity and the extent of traumatic injury. Since the development of high resolution CT, significant progress has been made for the evaluation of orbital trauma, adding more sensitivity to the plain x-ray method. Other imaging methods that can be useful is ultrasonography and MRI. The objective of this article is to review the orbital anatomy correlated with the common CT imaging patterns, and to establish the modality of choice in assessing orbital trauma.

Methods: We retrospectively analyzed 297 patients with facial trauma who were submitted to spiral CT scanning. The CT images were interpreted using the following protocols: axial, multiplanar reconstruction (MPR), 3D images and association of axial/MPR/3D images. We evaluated the anatomical sites of lesions, dividing them according to the orbital walls: lateral; medial; superior (roof) and inferior (anterior, medial).

Results: In our study 35% of patients who suffered facial trauma had ocular or orbital injuries. Most frequent site of orbital fractures was the medial wall. Association of axial/MPR images interpretation increase

the sensitivity of CT diagnosis compared with only axial protocol.

Conclusions: Facial traumatized patients with clinical suspicion of orbital injuries are usually first evaluated with spiral CT, the best protocol is to obtain thin-section (1-3 mm) axial CT scans and then performing multiplanar reformation (specially coronal reformation is very useful). Knowledge of diverse imaging patterns of potential injuries is essential to make a fast and accurate diagnosis of post-traumatic orbital injury.

Keywords: computer tomography, fracture, multiplanar reconstruction (MPR), orbital trauma

Background

Trauma to the eye is the cause of blindness in more than half a million people worldwide and of partial loss of sight in many more, and it is often the main cause of unilateral loss of vision in developing countries. For example, in the United States orbital trauma occurs in approximately 3% of all emergency department visits.

Orbital injuries are often seen in patients with multiple traumas from traffic accidents, assault, falls from height, gunshot.

A basic knowledge of the potential injuries to the eye and of the anatomy of

this region is necessary to determine the gravity and the extent of traumatic traumatic injury.

Imaging Options

Computed tomography (CT) is the method of choice for evaluating orbital trauma and it is useful for evaluating bone fractures, soft tissue injury and foreign body detection. CT is a fast method to perform, readily available, no special need for patient preparation, the eye movement do not degrade the image acquisition and has no risk if metallic fragment are suspected. CT has been shown to be more accurate than radiography in detecting fractures. When fractures are present, three-dimensional reformation is a useful tool to guide treatment.

Other methods may be useful for evaluating orbital trauma: radiography has a sensitivity of 64%–78% for a fracture, but it has very low sensitivity for soft-tissue injuries; ultrasonography (US) is very useful for evaluating the globe and its contents; but US is contraindicated if a ruptured globe is suspected and additionally is operator dependent and offers no information about bone trauma; magnetic resonance (MR) imaging may be difficult to perform and it is contraindicated if there is a possibility that a metallic fragment is present.

Methods

The study is a retrospective analysis of 297 patients diagnosed as having head trauma hospitalized between 2009 and 2010 at “Prof. Dr. Nicolae Oblu” Hospital, Iasi. The patients were submitted to spiral CT scanning. and CT images were interpreted using the following protocols: axial, multiplanar reconstruction (MPR),

3D images and association of axial/MPR/3D images.

We evaluated the anatomical sites of lesions, dividing them according to the orbital walls: lateral; medial; superior (roof) and inferior (anterior, medial).

Discussion – from anatomy to traumatic CT patterns

The orbit is a pyramidal space formed by seven bones: Frontal, Zygomatic, Maxillary, Ethmoidal, Sphenoid, Lacrimal, Palatine. The paired orbital cavities lie on each side of the midsagittal plane of the skull on close relation to the nasal sinus and cranial cavities. The volume of each adult orbit is about 30 cc. The orbital entrance averages about 35 mm in height and 45 mm in width.. In adults, the depth of the orbit varies from 40 to 45 mm from the orbital entrance to the apex.

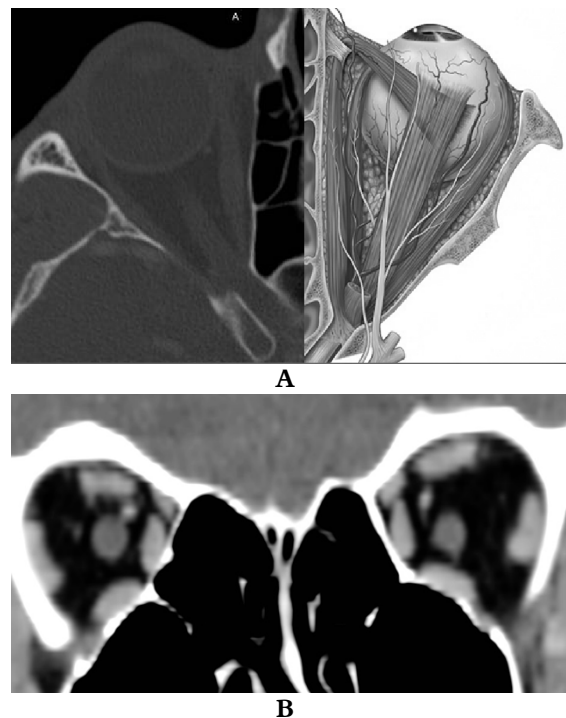


Figure 1 CT axial **A** and coronal **B** view of the orbit

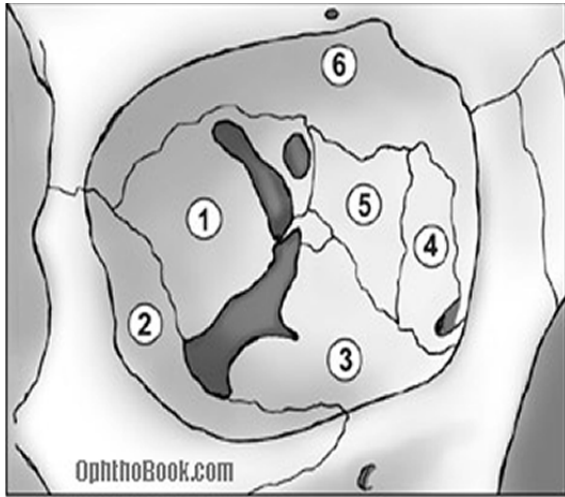


Figure 2 Bony orbit anatomy: 1 Sphenoid, 2 Zygomatic, 3 Maxillary, 4 Lacrimal, 5 Ethmoidal, 6 Frontal, 7 Palatine

The medial wall - is approximately rectangular and it is formed by 4 bones: the frontal process of the maxilla (that forms the medial orbital rim), the lacrimal bone, the orbital plate of the ethmoid, and the lesser wing of the sphenoid.

At its anterior aspect, it contains the lacrimal fossa which is bounded by the anterior and posterior lacrimal crests. The lacrimal sac is intimately related to the medial canthal tendon, which is a major supporting structure of the superficial tissues of the medial orbital region.

The vast majority of the medial wall is comprised of the lamina papyracea, a paper-thin bone overlying the ethmoid sinus that facilitates the infection spread in cases of ethmoid sinusitis, into the orbit; it is extremely thin, varying from 0.2 to 0.4 mm in thickness.

The most posterior part of the medial wall is formed by the thick bone of the sphenoid body, adjoining the optic canal. The medial wall articulates with the roof at the fronto-ethmoid suture and it articulates with the floor at the maxillo-ethmoid suture.

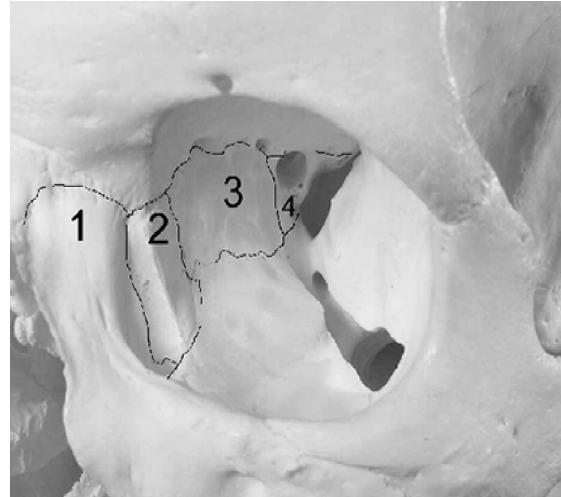


Figure 3 Medial orbital wall is formed by: 1 frontal process of the maxilla, 2 Lacrimal bone, 3 lamina papyracea, 4 sphenoid body

The lamina papyracea fractures easily in blunt orbital trauma and in the course of ethmoid sinus surgery, exposing the orbit to the risk of inadvertent surgical injury. Medial orbital wall trauma is strongly related with diplopia due to the mechanical entrapment of the medial rectus muscle (recognized on CT by displacement of the muscle into the fracture site, with or without bone displacement). CT scan also localizes the fragments of the fractured lamina papyracea even if the orbital sinus adjacent to the fracture is opacified. A degree of medial displacement of the lamina papyracea can be present, and the ethmoidal sinuses often are hyperdense due to edema and blood accumulation.

The orbital floor - is formed mainly by the orbital plate of the maxilla and with contributions from the zygoma anterolaterally and the palatine bone at its most posterior limit. The orbital floor is the roof of the maxillary sinus. In its posterolateral two-thirds, the floor is separated from the lateral wall by the inferior orbital fissure through which the maxillary division of the trigeminal nerve enters the orbit.

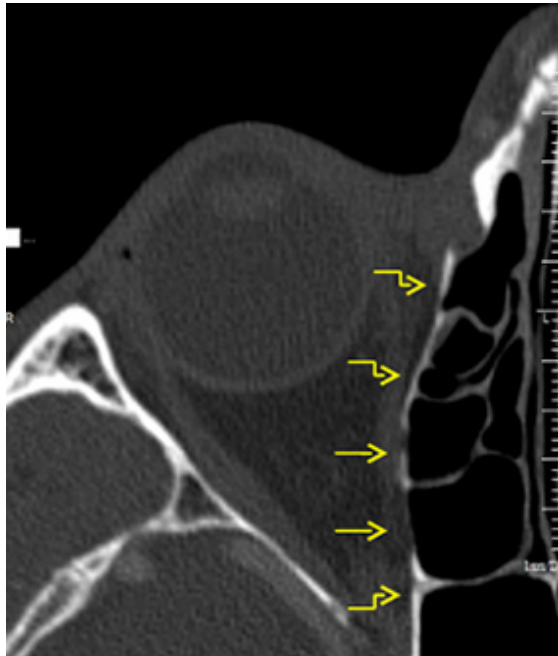
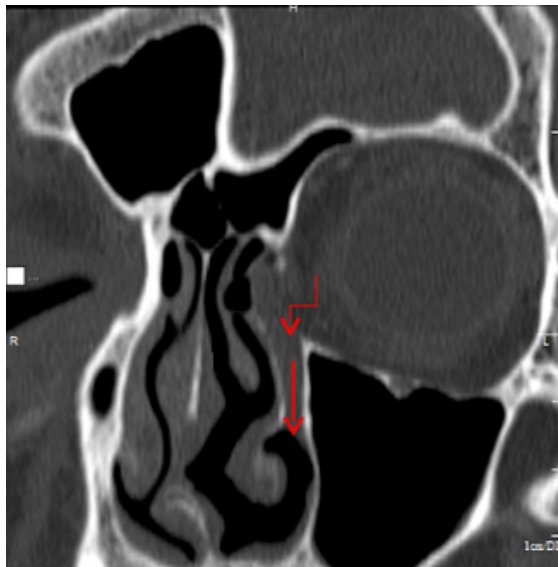
**A****B**

Figure 4 Important structures on medial wall **A** Axial nonenhanced CT image shows the normal anatomy of lamina papyracea, and **B** on coronal view, the nasolacrimal canal

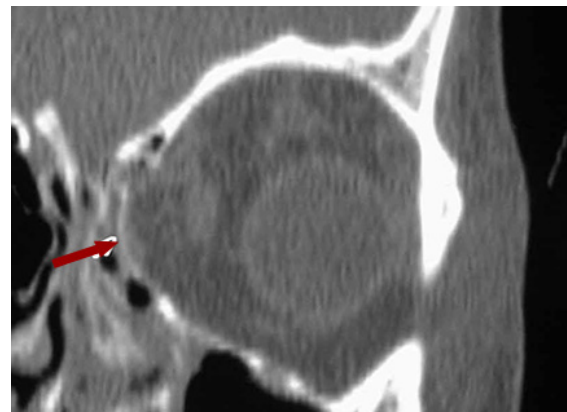
**A****B**

Figure 5 Fractures of the medial orbital wall **A** Axial nonenhanced CT image and **B** the coronal view show the displacement of the lamina papyracea with blood accumulation in adjacent ethmoidal cells

An important structure is represented by the the infraorbital groove which is the location of infraorbital nerve that supplies sensation to cheek and ipsilateral upper alveolus and teeth. Medial to the infraorbital nerve, the orbital floor is relatively thin and fractures easily.

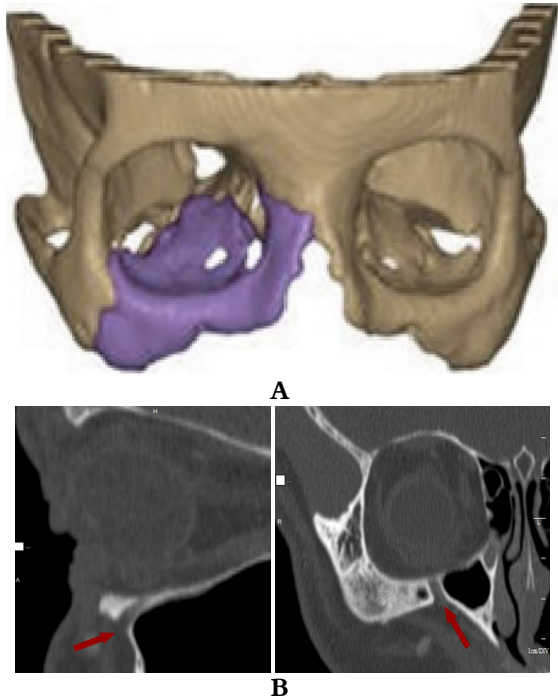


Figure 6 **A** The orbital floor, **B** the infraorbital groove on sagittal and coronal CT views

Orbital floor fractures can occur isolated, but they are also associated with Le Fort II fractures (orbital floor fractures) and NOE fractures (medial orbital wall fractures). Orbital floor fractures may result when a object, which is of equal or greater diameter than the orbital aperture, hits the eye, and the resultant force is transmitted throughout the orbit causing a fracture of the orbital floor.

The imaging study of choice is CT scan, with axial and coronal reconstruction (thin cuts - 2-3 mm - with specific attention to the orbital floor and optic canal).

The lateral wall - is the thickest of the orbital walls and is formed by the greater wing of sphenoid posteriorly and the zygoma anteriorly. It is separated from the floor by the inferior orbital fissure and from the roof by the superior orbital fissure (posteriorly) and the frontosphenoid suture.

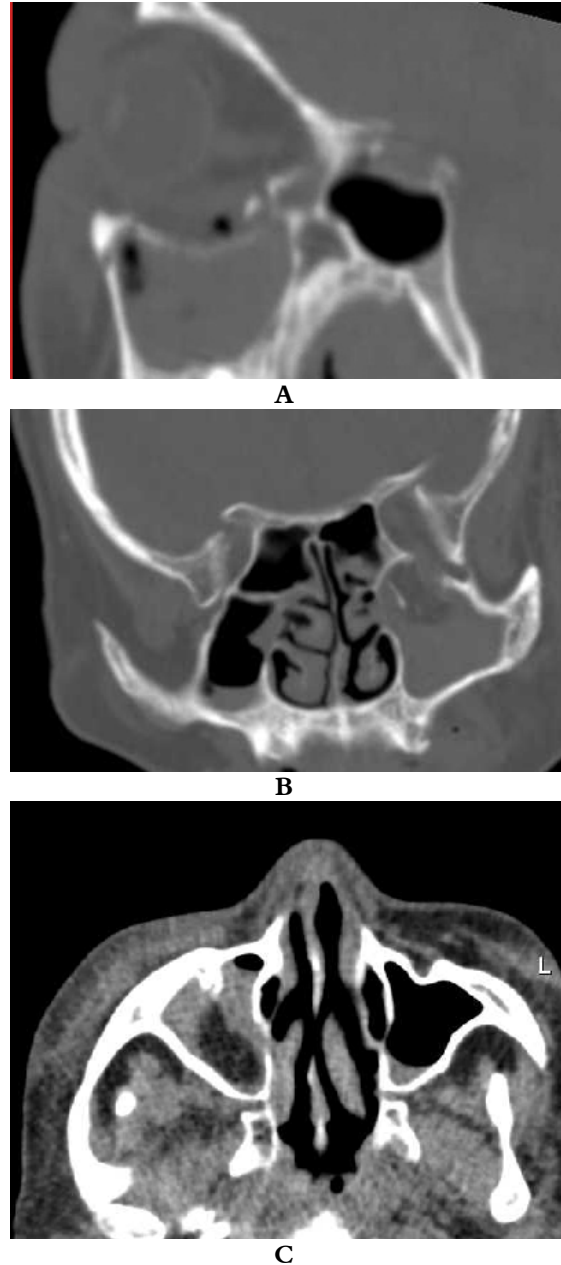
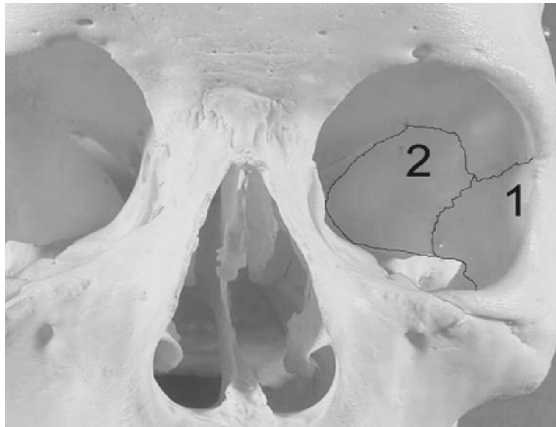
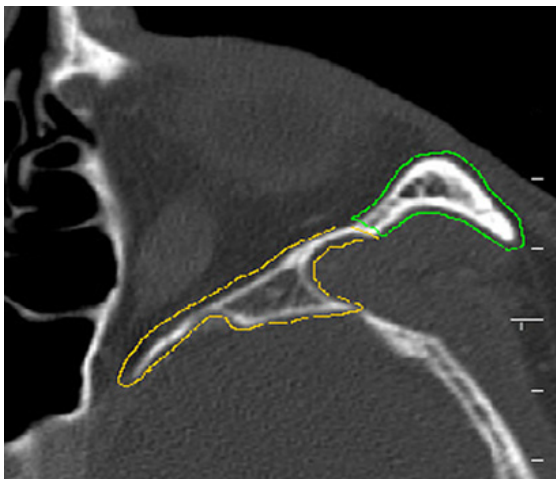


Figure 7 Fractures of the orbital floor. **A** Sagittal nonenhanced CT image shows a orbital floor fracture without evidence of entrapment of the inferior rectus muscle. **B** Coronal nonenhanced CT image shows a left orbital floor fracture. The inferior rectus is displaced inferiorly into the maxillary sinus. **C** Axial nonenhanced CT image shows the orbital fat herniation into the maxillary sinus



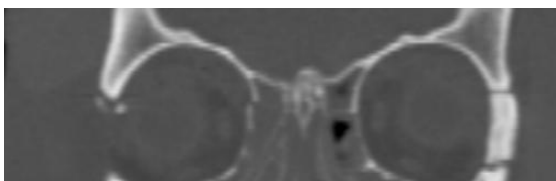
A



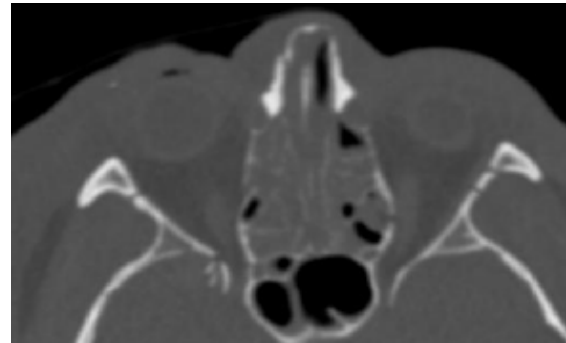
B

Figure 8 **A** Lateral orbital wall is formed by: 1 zygoma and 2 greater wing of sphenoid, **B** Axial nonenhanced CT image shows the lateral wall (with yellow the sphenoid and with green zygoma)

In its posterior part, the greater wing of sphenoid is interposed between the middle cranial fossa and the orbit. During lateral orbitotomy, the cut is usually made just above the frontozygomatic suture, at which point the middle cranial fossa is in close proximity.



A



B

Figure 9 Fractures of the orbital walls. **A** Coronal and **B** Axial nonenhanced CT image show fractures of the zygomatic bone that forms external wall of orbit

The orbital roof - is formed by the frontal bone with a minimal contribution from the lesser wing of sphenoid. It forms the floor of the anterior cranial fossa. The orbital roof is strong and rarely fractures. The lacrimal gland is located in a fossa in the anterolateral aspect of the roof.

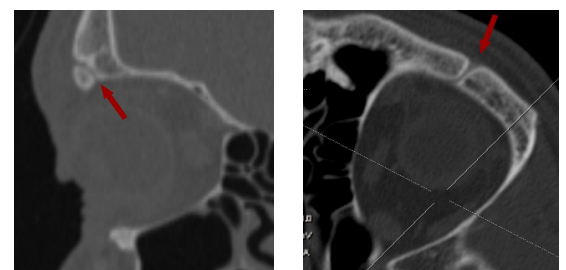


Figure 10 **A** Schematic representation of the orbital superior wall. **B** Sagittal and axial nonenhanced CT show the supraorbital notch which is the location of the homonym nerve

Isolated fractures of the orbital roof are uncommonly seen in the absence of a fracture of the superior orbital rim.

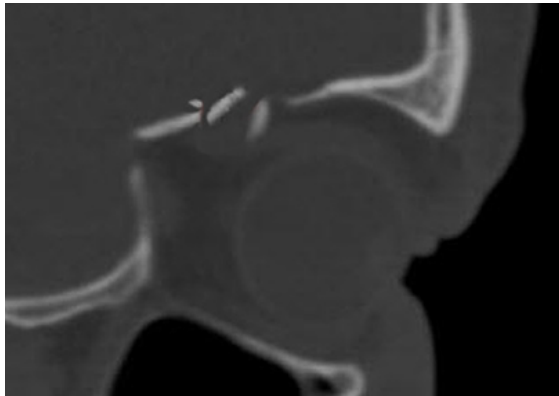
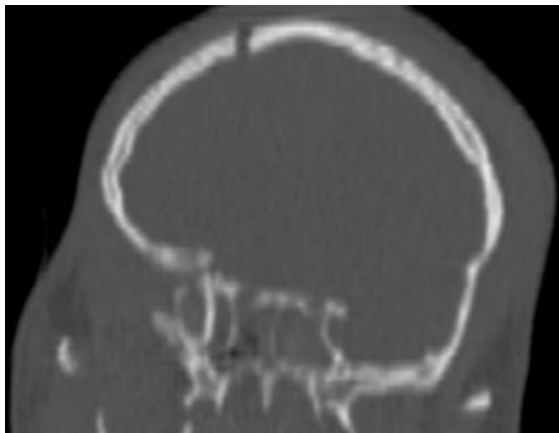


Figure 11 Coronal nonenhanced CT image shows a fracture of the midportion of the orbital roof with displacement of the fracture fragments intraorbital and into the cranial fossa



A



B

Figure 12 A and B 3D reconstructed and coronal views that show an important frontal bone fracture that is extended to the superior orbital wall

Conclusion

Facial traumatized patients with clinical suspicion of orbital injuries are usually first evaluated with spiral CT, the best protocol is to obtain thin-section (1-3 mm) axial CT scans and then performing multiplanar reformation (specially coronal reformation is very useful). Knowledge of diverse imaging patterns of potential injuries is essential to make a fast and accurate diagnosis of post-traumatic orbital injury.

References

1. Anderson JE. Grant's Atlas of Anatomy. Baltimore, Md: Williams & Wilkins; 1978
2. Bord SP, Linden J. Trauma to the globe and orbit. *Emerg Med Clin North Am* 2008;26:97-123.
3. Cooper PW, Kassel EE, Gruss JS. High-resolution CT scanning of facial trauma. *AJNR Am J Neuroradiol* 1983;4(3):495-498.
4. Daffner RH. Imaging of facial trauma. *Semin Musculoskelet Radiol* 1998;2(1):65-82.
5. Daniels DL, Pech P, Kay MC, et al. Orbital apex: correlative anatomic and CT study. *AJNR Am J Neuroradiol* 1985;6:705-710
6. Daniels DL, Rauschnig W, Lovas J, et al. Pterygopalatine fossa: computed tomographic studies. *Radiology* 1983;149:511-516
7. Gassner R, Tuli T, Hachl O, Rudisch A, Ulmer H. Cranio-maxillofacial trauma: a 10 year review of 9,543 cases with 21,067 injuries. *J Craniomaxillofac Surg* 2003;31(1):51-61.
8. Grant JH 3rd, Patrinely JR, Weiss AH, Kierney PC, Gruss JS. Trapdoor fracture of the orbit in a pediatric population. *Plast Reconstr Surg* 2002;109(2): 482-489; discussion 490-495.
9. Gruss JS, MacKinnon SE. Complex maxillary fractures: role of buttress reconstruction and immediate bone grafts. *Plast Reconstr Surg* 1986;78(1):9-22.
10. Iida S, Kogo M, Sugiura T, Mima T, Matsuya T. Retrospective analysis of 1502 patients with facial fractures. *Int J Oral Maxillofac Surg* 2001;30(4):286-290.
11. Inuma T, Hirota Y, Ishio K. Orbital wall fractures: conventional views and CT. *Rhinology* 1994;32:81-83.

12. Laine FJ, Conway WF, Laskin DM. Radiology of maxillofacial trauma. *Curr Probl Diagn Radiol* 1993;22(4):145–188.
13. Markowitz BL, Manson PN, Sargent L, et al. Management of the medial canthal tendon in nasoethmoid orbital fractures: the importance of the central fragment in classification and treatment. *Plast Reconstr Surg* 1991;87(5):843–853.
14. Rene C, Rose GE, Lenthall R, Moseley I. Major orbital complications of endoscopic sinus surgery. *Br J Ophthalmol* 2001; 85: 598–603.
15. Rhea JT, Rao PM, Novelline RA. Helical CT and three-dimensional CT of facial and orbital injury. *Radiol Clin North Am* 1999;37:489–513.
16. Simonton JT, Garber PF, Ahl N. Margins of safety in lateral orbitotomy. *Arch Ophthalmol* 1977; 95: 1229–1231.
17. WHO Geneva. Strategies for the Prevention of Blindness in National programmes. A Primary Health Care Approach, 2nd edn. WHO Library Cataloguing: England, 1997, pp 74–76.
18. Williams PL, Warwick R, Dyson M, Bannister LH, eds. *Gray's Anatomy*. 35th ed. London: Churchill Livingstone; 1989:346–347
19. Wolff E, ed. *Anatomy of the Eye and Orbit*. 7th ed. Philadelphia, Pa:WB Saunders; 1976
20. Yeh S, Foroozan R. Orbital apex syndrome. *Curr Opin Ophthalmol* 2004; 15: 490–498
21. Zide BM, Jelks GW. *Surgical Anatomy of the Orbit*. New York, NY: Raven Press; 1985