Skull Base Fractures and Their Complications

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KEYWORDS

• Skull base trauma • CSF leak • Basilar skull fracture • CSF rhinorrhea

KEY POINTS

- Skull base fractures are managed based on associated intracranial injury and complications, including vascular and cranial nerve injury and cerebrospinal fluid (CSF) leak.
- Anterior cranial fossa fractures, particularly comminuted and oblique frontobasal fractures, are commonly associated with CSF leak, either acute or delayed in presentation.
- Transverse middle cranial fossa fractures extending through the carotid canal are at increased risk for vascular injury, and should prompt screening with vascular studies, such as CT angiography.
- Thin-section multiplanar CT reformations, as well as 3-dimensional reconstructions, are helpful in the detection of subtle skull base fractures.

INTRODUCTION

Head trauma is one of the most common reasons for visits to the emergency department in the United States. According to the 2013 National Trauma Data Bank maintained by the American College of Surgeons, of 833,311 adult trauma admissions reported from 805 facilities across the United States, approximately 36% sustained an injury to the head.[1] Skull base fractures, those fractures that extend through the floor of the anterior, middle, or posterior cranial fossa, occur in an estimated 7% to 16% of nonpenetrating head injuries, and are due to a relatively high-velocity trauma, most often high-speed motor vehicle accidents, although motorcycle collisions, pedestrian injuries, falls, and assault are additional associated causes.[2] Penetrating trauma, particularly gunshot wounds, are seen much less frequently, accounting for less than 10% of cases.[3]

Skull base injury is often seen in the setting of complex facial or orbital fractures, and detection of basilar skull fractures is important, as even linear nondisplaced fractures can be associated with numerous critical complications, including intracranial and orbital injuries, cerebrospinal fluid (CSF) leak, cranial nerve palsies, and vascular injuries. Although facial fractures often require repair to improve function and cosmesis, the management of patients with skull base injury is dependent on the extent of associated intracranial injury and other complications. The associated risk and extent of complications often depends on the location and pattern of the fracture, which is in turn determined by the mechanism of injury and type of impact.

NORMAL ANATOMY

The skull base is made up of 7 bones, the paired frontal and temporal bones, and the unpaired ethmoid, sphenoid, and occipital bones. It is divided into anterior, central, and posterior regions, which form the floor of the anterior, middle, and posterior cranial fossae.

The anterior skull base, formed by the frontal and ethmoid bones, separates the anterior and inferior frontal lobes and olfactory structures within

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Neuroimag Clin N Am 24 (2014) 439–465
http://dx.doi.org/10.1016/j.nic.2014.03.001

the anterior cranial fossa from the orbits and the sinonasal cavity. The lateral and anterior borders of the anterior cranial fossa are formed by the orbital plate of the frontal bone and the posterior table of the frontal sinus. Inferiorly, the floor of the anterior cranial fossa is formed by the cribriform plates and roof of the ethmoid sinuses. The posterior border between the anterior and central skull base is formed by the lesser wing of the sphenoid bone, including the clinoid process, and the planum sphenoidale (Fig. 1).

Deep clefts lateral to the midline crista galli form the olfactory grooves, which house the olfactory bulbs. The floor of the olfactory groove is formed by the cribriform plates, which are inherently thin, with multiple small foramina through which the small branches of the olfactory nerve pass. The lateral lamella is a thin bone connecting the cribriform plate with the fovea ethmoidalis, or the roof of the ethmoid sinuses, all part of the ethmoid bone. In addition to the cribriform plate foramina, the anterior skull base contains the anterior and posterior ethmoid artery foramina, which should not be confused with fractures; these may represent significant sources of epistaxis, if injured (Fig. 2).

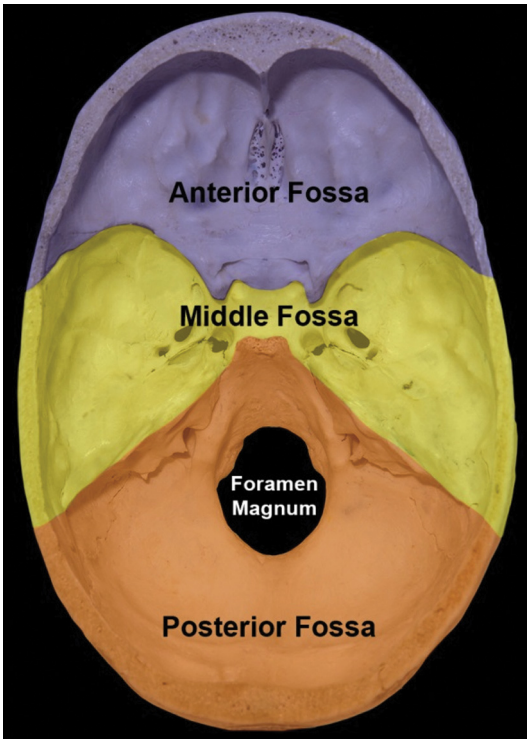

Fig. 1. Axial photograph of the skull base with overlays demonstrating the anterior, middle, and posterior cranial fossae. (*Courtesy of* Kevin Makowski and Eric Jablonowski, Emory University, Atlanta, GA.)

The central skull base, formed by the sphenoid and anterior temporal bones, separates the pituitary gland (within the sella), the cavernous sinuses (including the carotid artery and cranial nerves), the Meckel cave, and the temporal lobes superiorly from the sphenoid sinus anteriorly and inferiorly, and the extracranial soft tissues deep to the skull base inferiorly, including the masticator, parotid, parapharyngeal, and pharyngeal mucosal spaces. The anterior border of the central skull base is formed by the posterior margin of the lesser wing of the sphenoid bone, clinoid process and tuberculum sella. The floor is formed by the greater wing and central body of the sphenoid bone, the sphenoid sinus, and the sella. The posterior border between the central and posterior skull base is formed by the superior margin of the petrous ridge of the temporal bone, the basi sphenoid portion of the clivus, and the dorsum sella (see Fig. 1). In addition to housing the pituitary gland, the central skull base contains numerous foramina and canals through which many important structures pass, including cranial nerves (CNs) II to VI and the internal carotid artery (Fig. 3, Table 1).

The posterior skull base is formed by the posterior temporal bone and the occipital bone, and separates the posterior fossa structures, including the cerebellum and brainstem, from the extracranial soft tissues: the posterior nasopharynx, retropharyngeal space, carotid space, and perivertebral space. The anterior border is formed by the petrous ridge of the temporal bone superiorly, and the clivus (basi occiput portion) inferiorly. The inferior border includes the occipital condyles and the mastoid portion of the temporal bone, and the posterior skull base extends posteriorly to the squamous portion of the occipital bone (see Fig. 1). Some consider the temporal bone proper to be the lateral, or posterolateral skull base.

The largest foramen of the skull base, foramen magnum, is located within the posterior skull base, and transmits the medulla oblongata (cervicomedullary junction), vertebral arteries, and spinal portion of CN XI. Other major foramina within the posterior skull base include the internal auditory canal (CN VII, VIII, and labyrinthine artery), jugular foramen (pars nervosa anteriorly: CN IX, inferior petrosal sinus, and Jacobsen nerve; pars vascularis posteriorly: CN X, XI, Arnolds nerve and jugular bulb), and hypoglossal canal (CN XII) (Figs. 4 and 5).

PATHOLOGY

Fractures through the skull base are often the sequelae of high-velocity impact and may be linear