Prevention and Management of Skull Base Injury

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KEYWORDS

• Skull base injury • Skull base defect • CSF leak
• Microdebrider • Ethmoid defect

Skull base defects and injuries are rare, but may occur during endoscopic sinus surgery, as a result of facial trauma, or as a result of tumors in the anterior cranial fossa. Iatrogenic injuries resulting in CSF leaks through skull base defects have been noted to have an incidence of 0.46% to 0.85%.[1,2] Injury to the skull base can lead to catastrophic outcomes that include meningitis, brain abscess, neurologic deficits, brain hemorrhage and death. This content discusses ways in which a surgeon may work to prevent or minimize injury to the skull base. We also describe management of these injuries when they do occur, review the current literature, and describe various reconstruction techniques.

PREVENTION

If unrecognized, anatomic variations may contribute to surgical complication along the anterior skull base. One such anatomic variation that may occur along the ethmoid roof is described by the Keros classification, which measures the vertical height between the cribriform plate and the fovea ethmoidalis (**Table 1**).[3] In this classification, the depth of the olfactory fossa is categorized as 1 to 3 mm (Keros I), 3 to 7 mm (Keros II), or 7 to 16 mm (Keros III). As the bone in this region is typically quite thin, increased vertical height lends itself to increased vulnerability. In Keros' original study of 450 cadavers, 12% were found to be Keros I, 70% Keros II, and 18% Keros III. This proportion has been supported by several recent CT studies.[4,5] Also notable in recent studies has been asymmetry of greater than 2 mm in 8% of patients (**Fig. 1**).[5]

Pre-operative CT scans may also be evaluated for the presence of a low-lying skull base. Meyers and Valvassori found that a horizontal line drawn along the roof of the ethmoid passed above the vertical mid-point of the orbit in 88% of the cases studied. Approximately 10% of cases crossed the orbit at the vertical midplane and 2% of

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Table 1
Keros classification

Classification	Depth of the Olfactory Fossa
Type I	1–3 mm
Type II	3–7 mm
Type III	8–16 mm
Asymmetric	Asymmetric

cases were below the vertical midplane.[6] Stankiewicz and Chow built on this data from Meyers and Valvassori's study to develop safety zones based on the relationship of the skull base to the level of the orbit. **Fig. 2** depicts this concept with zone 1 being the safest. When the horizontal line drawn from the roof of the ethmoid crosses the upper one-third of the orbit, this is considered the most safe anatomic arrangement.[7] Caution is to be used in cases in which the ethmoid roof crosses below the midplane of the orbit.

Other anatomic considerations when working along the skull base include the extent of sinus disease. Extensive disease can affect visualization during surgery due to increased inflammation and consequent intra-operative bleeding. Intra-operative bleeding has been noted to be significant in several case series that discussed iatrogenic skull base injuries, and this bleeding may be related to the extent of inflammation and sinus disease.[7,8] On the other hand, DelGaudio and colleagues[9,10] found that 74% of skull base injuries occurred in patients with minimal or no mucosal disease. They postulated that injury was a result of less resistance and thinner bone in the less diseased sinuses. Diseased sinuses may have thicker bone as a result of sinus oteoneogenesis.

Use of powered instruments, such as the microdebrider, are commonplace in the surgical management of sinus disease. A microdebrider suctions while a rotating blade cuts through the tissue suctioned into the device. Consequently, a significant amount of tissue can be removed quickly. Due to this aggressive cutting nature, a microdebrider should be used very judiciously along susceptible areas such as

Fig. 1. Asymmetric cribriform plate with Keros Type III.