1. Discuss the physiology of the nasofrontal duct. AL

Drainage of the frontal sinus is complex with its outflow tract resembling an hourglass-shaped structure in the sagittal plane. The narrowest portion of the outflow tract is the frontal ostium (1,2). The superior portion widens into the frontal sinus and the inferior portion expands into the frontal recess. The variability of the frontal sinus outflow tract drainage pattern depends on the pneumatization of the surrounding ethmoid air cells and the position of the uncinate process.

The frontal sinus drains through the frontonasal opening, usually located in the posteromedial aspect of the floor. The course of the frontonasal outflow tract is posterior and caudal.

Development of the frontal sinus begins between the ages of two and four when the anterior ethmoid cells expand into the frontal bone. The frontal sinuses are radiographically evident by ages five to eight and reach full adult size between ages twelve and eighteen. The anatomy of the frontal sinus is highly variable. They are funnel shaped sinuses and communicate with the middle meatus via an hourglass-like narrowing called the nasofrontal duct. Mucus in the frontal sinus flows up the medial wall, laterally across the roof, medially along the floor, and down the nasofrontal duct into the middle meatus. The nasofrontal duct often does not consist of bony walls of its own, and its borders are defined by the bony walls of neighboring structures. Because it is not always a true duct, it is thus frequently referred to as the frontal recess.

In approximately 15% of the population, a true duct nasofrontal duct exists. These ducts are located in the posterior-medial portion of the frontal sinus floor and vary in length from several millimeters to 2-3 centimeters. They travel anterior-inferiorly and empty into the anterior middle meatus. Longer ducts are more susceptible to injury in facial trauma. In most patients (up to 85%), the frontal recess is not a tubular structure but an
ostium that drains directly into the middle meatus. It is bordered anteriorly by the agger nasi cell, laterally by the orbit, and medially by the middle turbinate. When the ethmoid bulla reaches the skull base, it forms the posterior boundary of the frontal recess. When it does not reach the skull base, the suprabullar recess communicates directly with the frontal recess and the anterior ethmoid artery defines the posterior margin. The patency of the frontal recess depends upon several factors, including the superior articulation of the uncinate process, the agger nasi cell, the presence or absence of frontal cells, the presence of supraorbital cells, and the ethmoid bulla.

### Frontonasal Drainage

The relation between obstruction of the frontonasal outflow tract and formation of frontal mucoceles has been established. Experiments with animals have shown that mucocele of the frontal sinus forms if the frontonasal outflow tract is obstructed or when inadequate removal of the mucosa occurs. The frontonasal outflow tract is small and cannot be evaluated confidently before surgery, even with the help of CT. The best evaluation of frontonasal outflow tract integrity and patency is made intraoperatively. Frontal sinus exploration is recommended if injury to the frontonasal outflow tract is suspected.

Patency of the frontonasal outflow tract can be evaluated with fluorescein, benzylpenicillin solution (white), or methylene blue dye. Intranasal presence of the substance when it is introduced into the frontonasal outflow tract superiorly indicates the frontonasal outflow tract is patent. Interpretation of this test result is difficult in the presence of anterior ethmoidal fractures and swelling of the nasal mucosa.

2. How would you assess the viability of the nasofrontal duct in frontal sinus fracture? CB

3. List the acute and late complications following frontal sinus fracture? What is the most common late complication and how would you manage it? Could it have been avoided? Laryngoscope 1988;98:516 and Plast Reconstr Surg. 1988;82:781-791. AL

Laryngoscope: Comparison of complications following frontal sinus fractures managed with exploration with or without obliteration over 10 years
- 40 Fx’s displaced, 25 Fx’s compound, 20 Fx assoc. w CSF leak
- 46 Pts had frontal sinus obliteration
- 18 Pts had open exploratory surgery
- 1 Pt had frontal sinus trephination, 1 Pt refused surgery
- Isolated anterior wall Fxs -> ORIF
- Nasofrontal duct trauma -> frontal sinus obliteration
- Posterior wall Fxs-> obliteration

Complications: chronic frontal headaches, sinus infections, frontal sinus fullness, chronic sinus drainage, forehead depression, post op wound infection, diplopia, new onset seizure, brain abscess,
Early complications usually occur within 6 months and include frontal sinusitis, most commonly resulting from retained foreign bodies or bony chips; wound infections, meningitis; and, CSF leak (rates as high as 10% in some studies).

Late complications may occur up to a decade after injury and include chronic frontal headaches, forehead depression, mucocele, mucopyocele, delayed CSF leak, or brain abscess, which is caused by spread of infection from the frontal sinus intracranially through foramina of Breschet.

Chronic frontal headache is the most common late complication (reported by almost one third of the patients in Wilson’s study). In most studies, rates of chronic headache are actually slightly higher in treated groups when compared with non-treated groups. Grossman postulates that it is possible that headaches resulting from frontal sinus fracture are caused by injury to the supraorbital nerve, and the frequency of this complication emphasizes the need to carefully preserve the nerve during fracture repair.

Because the most common presentation of serious long-term complications is frontal headache, any complaints of frontal pressure, pain, or headache in a patient with a history of frontal sinus fracture should lead to an aggressive workup. CT scanning provides the most accurate diagnostic information when evaluating a patient for complications.


6. A 25-year-old man sustains a fracture of the frontal sinus in a motor vehicle collision. CT scans reveal an anterior table fracture that involves the nasofrontal duct. Discuss the options. Laryngoscope 2002;112:784-90. AL

Objective: to evaluate alternative management strategies for anterior table frontal sinus fractures involving the frontal sinus outflow tract.

Prospective study 1999-2001: 7 Pts w anterior table frontal sinus Fx w involvement of the frontal outflow tract treated with open reduction w/o obliteration of the frontal sinus.

5 Pts then had spontaneous frontal sinus ventilation
2 Pts had persistent frontal sinus obstruction and then underwent extended endoscopic frontal sinusotomy or a modified endoscopic Lothrop procedure.
Traumatic disruption of the frontal sinus outflow tract can result in scarring and long-term complications including mucocoele formation or chronic sinusitis as a result of outflow obstruction. Two treatment options are generally considered: 1) surgically enlarging the ostium to promote patency or 2) sinus obliteration (or osteoplastic flap with obliteration).

This is a prospective study out of Medical College of Wisconsin looking at patients with anterior table frontal sinus fractures involving the frontal outflow tract between 1999 and 2001. Select patients were treated with open reduction without obliteration of the frontal sinus. A modified algorithm including reduction of bony fragments with rigid internal fixation without obliteration, 4 weeks of postoperative abx, serial post-op CT scans at 8 wks, 16 wks, 6 months, and 1 year and a contingency of endoscopic frontal sinus surgery for persistent frontal sinus outflow tract obstruction were offered to patients and 7 elected to proceed.

All 7 pts had associated facial fractures (5 superior orbital rim, 4 nasal bone, 2 NOE, 2 ZMC, 2 midface, 1 nasal septal). All patients had fractures managed within 72 hours. 5 of 7 patients had spontaneous ventilation of the frontal recess and sinus with observation and adjunctive medical therapy. The other 2 patients, both of whom had NOE fractures as well, developed persistent outflow obstruction and chronic sinusitis. First, maximal medical management was attempted with an additional 4 weeks of abx, systemic steroid taper, and topical steroid spray. When medical management failed, endoscopic management was undertaken with one patient undergoing a Draf II and the other a Draf III procedure. The frontal sinuses were still patent in both patients at 21 and 25 months.

This group argues that endoscopic management is advantageous (over osteoplastic flap with obliteration) because it avoids external scars/surgical morbidity, avoids supratrochlear and supraorbital nerve injury that can lead to paresthesias or neuralgias and headaches, allows endoscopic evaluation in the clinic rather than repeat CT scans which can often be confusing in the setting of obliteration due to the variable appearance of fat, granulation tissue, fibrosis and fluid.

7. You are called to the trauma bay to evaluate a 30-year-old female with a frontal sinus fracture. A CT scan shows a comminuted fracture of the anterior table and a linear non-displaced fracture of the posterior table. There is no evidence of cerebrospinal fluid leak. How would you manage this patient? TT


10. How would you manage the frontal sinus mucosa during an obliteration or cranialization procedure? Support your answer with data. HH