Frontal Sinus Fractures

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Grand Rounds Presentation
December 17, 2010
Outline

- History
- Introduction
- Etiology
- Work up
- Treatment
First described by Reidel in 1898

- Performed a total exenteration by removing the anterior table and floor, which left the skin covering the posterior table, which left a cosmetic defect.
- Killian in 1904 performed a similar procedure, but left a rim of supraorbital bone which lessened the cosmetic defect.
- Lynch in 1921 was credited with the first frontoethmoidectomy—leaving the anterior table in place but removing the frontal sinus floor and ethmoids.
The first osteoplastic flap procedure was described in 1951 by Bergara and Itoiz, by exposing the sinus with a inferiorly based anterior table flap pedicled to pericranium.

This flap was later improved upon by Goodale and Montgomery by their invention of ablative frontal sinus surgery using autogenous fat.
Later it became clear that simple obliteration was insufficient and that the mucosa needed to be completely removed to prevent late sequelae.

In 1978 Donald and Bernstein describe the first cranialization. Their procedure involved stripping the sinus of all mucosa and plugging the nasofrontal ducts, and removing the posterior table.
Frontal sinus is absent at birth

By the age of 2 years, the anterior ethmoids begin to form the frontal sinus

At about 15 years of age, the frontal sinus is adult size
In the average adult, the frontal sinus is 30 mm tall, 25 mm wide, and 19 mm deep. Total volume of 10 cm$^3$. 

- Introduction
Introduction

- The frontal sinus is commonly bilateral, pyramidal and asymmetric in shape with the base forming the medial portion.

- The sinus is unilateral 10-20% of the population and absent in 4% of the population.
Introduction

- **Anterior table**
  - Forms brow, forehead, and glabella, average 4 mm, but can be up to 12 mm thick. This allow it to resist facial fractures more than any other bone.

- **Posterior table**
  - Creates the anterior cranial fossa. Its thickness is only 0.1-4.8 mm thick.
Introduction

- The sinus has 2 ostia on the posterior floor. They are each 3-4 mm in diameter and create the sole drainage for the sinus.
- They drain into the ethmoid infundibulum.
- Only 15% of the population have a true duct, in 85% it is just a foramen.
The arterial supply is from the supraorbital and supratrochlear vessels.

Venous drainage is through the facial vein, the ophthalmic vein/cavernous sinus, and through the foramina of Breschet.

Sensory innervation comes from V1 of the trigeminal nerve.
Etiology

- It takes 800-2200 lbs. of force to create a frontal fracture.
- They consist of 5-12% of facial fractures.
- Incidence is 9 cases per 100,000 adults.
Etiology

- Frontal fractures are grouped into 3 different general categories:
  - Anterior table fracture
  - Posterior table fractures
  - Combined fractures
Etiology

- Isolated anterior table fractures account for 33-39% of frontal sinus fractures.
- Anterior table fragment displacement can cause obstruction of the nasofrontal duct, especially in the base of the sinus.
- Also, this displacement can lead to depression of the forehead and cosmetic deformity.
Anterior table fracture
The anterior table also serves as the frontal bar for the horizontal buttress system of the facial skeleton. This helps maintain the horizontal dimensions of the face and provides stability to the vertical buttress system which is used for mastication. Therefore fractures of the frontal sinus not only disrupt the aesthetic contour of the face, but may disrupt mastication.
VERTICAL BUTTRESSES
1. Nasomaxillary
2. Zygomaticomaxillary
3. Pterygomaxillary
4. Vertical mandible

HORIZONTAL BUTTRESSES
A. Frontal bar
B. Inferior orbital rim
C. Hard palate
Etiology

- Isolated posterior fracture occur in <6% of fractures, whereas combined fractures of the anterior, posterior and/or nasofrontal recess occur in 55-67% of fractures.
- As many as 33% of patients have associated CFS leaks
- When the posterior table is displaced more than the width of the table, then the chance of CSF leak is higher.
Complications of untreated frontal sinus fractures are placed into acute and chronic changes.

- Acutely, <6 months:
  - Frontal sinusitis
  - Wound infections
  - Meningitis
  - CSF leak
Etiology

- Chronic complication
  - Chronic frontal headaches
  - Forehead depression
  - Mucocele/mucopyocele
  - Delay CSF leak
  - Brain abscess
  - Chronic nasal drainage
  - Frontal fullness
  - Diplopia
Workup

- Symptoms of initial presentation include:
  - Forehead swelling, pain and paresthesia
  - Forehead lacerations
  - Concave frontal bone contour
  - CSF rhinorrhea
Workup

- Patients usually present with associated trauma and must be triaged appropriately.

- Initial evaluation includes airway, breathing, circulation (ABCs)

- A neurosurgical and ophthalmological consultation should also be done if suspected frontal sinus damage.

- Patients present with coma 20-76% of the time.

- 93% have multiple facial fractures
After the patient is stabilized, a thorough head and neck examine is warranted.

Anterior displaced fractures may no be initially be apparent in physical exam due to soft tissue swelling or hematoma.

Forehead lacerations should be explored to assess the integrity of the frontal sinus.

Clean and examine the nasal cavity for CSF rhinorrhea.

Palpate the nasal bones for crepitus and step off deformity.

Evaluate the medial canthal tendon.
If there is concern for CSF leak, beta-2 transferrin test is the definitive test for evaluation.

One millimeter of suspected fluid should be sent out. Beside CSF, vitreous humor of the eye and perilymph of the ear have been found to have Beta-2 transferrin.

Also, a halo sign may be used to test for CSF.

Routine chemistry may also reveal elevated glucose.
Workup

- Radiographically, plain films may reveal frontal sinus opacifications or bony step offs, but the gold stand is CT. This is due to the fact that before routine CT scans, 50% of frontal sinus fractures were diagnosed after the patient left the ED.

- A thin cut axial and coronal CT (1.5 mm) should be ordered
  - Axial images reveal location, severity, and degree of comminution of the anterior and posterior table fracture
  - Coronal images reveal fractures of the sinus floor and orbital roof
Sagittal views are also helpful in evaluation of nasofrontal ducts.

Role of the sagittal view of computed tomography in evaluation of the nasofrontal ducts in frontal sinus fractures.
The management of frontal sinus fractures still remains somewhat controversial. However, general principles due apply.

Surgical treatment should be initiated in the first 12-48 hrs. is possible. This reduces the incident of long term complications.

It has also been reported that with patients with CSF leaks, leaks longer than 8 days increase rate of infection, and therefore early surgical repair, if indicated, would reduce the rate of infection.
Anterior table fractures

- Non-displace anterior table fractures can be managed nonsurgically with observation.

- Anterior table displacement or depression indicate surgical exploration and internal fixation. These fractures may form mucoceles, especially if base of sinus is involved.

- Also, during surgery, the nasofrontal duct should be explored and obliterated if involved.
Treatment

Anterior Table Fractures

Yes \rightarrow Displaced

No

Nasofrontal duct involved

Yes

Reduction Stabilization
Obliteration vs Cranialization

No

Reduction Stabilization

Observation
Posterior table fractures

- Posterior fractures, which are usually associated with anterior fractures, are dictated by nasofrontal duct and CSF leak.

- Conservative treatment of nondisplaced CSF leak includes bed rest, head of bed elevated, and lumbar drain at 10 ml CSF per hr.

- Surgery is advocated if the posterior table is displaced more than one table length. Also, surgery is indicated if CSF leak does not respond to conservative treatment of over 7 days.
Treatment

Posterior Table Fractures
(usually in combination with anterior table fracture)

Displaced more than one table width

Yes

CSF leak

No

Nasofrontal duct involved

Yes

Reduction and stabilization with obliteration vs cranialization

No

Reduction and stabilization of anterior wall

No

Observation for up to 7 days if no resolution, consider dural repair with or without cranialization

Observation
In posterior table fractures, Mild comminution without CSF leak requires osteoplastic flap and sinus obliteration.

Moderate to severe comminution, >30% of the posterior table, requires cranialization with a pericranial flap for dural repair as necessary.
Treatment

- Intraoperative nasofrontal duct exploration should always be attempted when undergoing surgery
- Exploration with a gently probe
- Fluorescein dye or methylene blue may be administered to check for patency after mucosal vasoconstriction
- Repair of nasofrontal duct has been poor, with 30% success rate.
All patients should be counseled about risk involved with the surgery which include:

- External scar
- Bleeding, pain, infection
- Forehead paresthesia
- External deformity
- Diplopia,
- CSF leak, meningitis
- Mucocele formation and sinusitis
Gossman, Laryngoscope 2006

- Reviewed 96 cases-48 Anterior frac, 48 Combine frac
- Observation in 47%
- ORIF 30%
- Cranilization 11%
- Obliteration 8%
Treatment

- ORIF of the anterior plate requires coronal incision approach
- Titanium vs absorbable plates are typically used to stabilize the fracture
- Miniplates are overall best for strength vs midface and microplates
- No difference in bio-absorbable vs titanium except in miniplates
Endoscopic

- Used for isolated anterior table fractures with no nasofrontal duct involvement
- One central and two lateral hairline incision are made.
- Soft tissue is elevated by visualization of 30° Scope.
- A skin incision is made through the brow and skin hooks used to reduce fragments, and then titanium mesh plates are used to stabilize the fracture
Endoscopy

  - Endoscopic transnasal reduction of the anterior table.
  - Use special balloon dilator into frontal sinus to reduce fracture under image guidance and 25° and 70° endoscopy
  - Left balloon dilator for 20 days to maintain reduction
  - Reduction successful with no cosmetic deformity
Advantages of endoscopic surgery

- Less invasive
- Minimal or no external incisions
- Shorter operative times
- Reduced hospital stay
- Easier postoperative monitoring
Indications for obliteration include
- Nasofrontal duct disruption
- Mucopyocele, chronic sinusitis
- Significant displaced posterior table fractures
- Loss of anterior frontal sinus tissue
- Epidural abscess/ Meningitis
- Tumor
Obliteration

- Involves removal of all visible mucosa
- Must remove inner cortex
- Occlusion of the nasofrontal duct
- Material that forms a barrier btw sinus and nasal cavity
Obliteration

- Material include
  - Adipose tissue
  - Hydroxyapatite
  - Pericranium
  - Bone chips
  - Temporalis fascia
  - Calcium phosphate cement
  - Glass ionomers
Obliteration

- **Hydroxyapatite**
  - Described Friedman and Costantino (1991)
  - 30% of Hydroxyapatite replaced with bone at 12 months, 68% replaced at 18 months.

- **Pericranial flap obliteration**
  - Vascular but does not rely on sinus wall
  - Anterior supraorbital flap, lateral anterior superficial temporal artery
Obliteration
Obliteration

Fig. 1. Intraoperative photograph showing the temporal muscle and fascia with a generous pericranial flap elevated from the temporal fossa.
Obliteration

- Parhiscar, Laryngoscope 2002
  - Use of pericranial flap between the posterior frontal sinus and the nasalfrontal duct with use of hydroxyapatite reduces retrograde infections

- Rohrich, Oto Head Neck Sur 2001
  - Compared avascular flaps vs pericranial flaps
  - Vascular flap less reabsorption, less infection, increased donor site morbidity
  - Obliterization success depends more on technique than tissue type, therefore occlusion of nasofrontal duct and complete removal of mucosal tissue more important than tissue type.
Obliteration

- Calcium phosphate cement
  - More soluble than hydroxyapatite, which facilitates resorption
  - Osteoconductive characteristics make it remodel similar to bone.
  - However, it is prone to degradation and chronic foreign body reactions when placed directly over dura, and therefore not recommended for frontal sinus work.
Obliteration

- Glass ionomer
  - Matrix of glass polymer, osteoconductive material
  - Better bone fill, faster healing time than hydroxyapatite
  - Only commercially available alloplast recommended for obliteration of the frontal sinus
  - No long term studies, but short term favorable with no foreign body reactions, resorption, or inflammation.
Obliteration

- Fat obliteration
  - Weber, Laryngoscope 2000
    - Fat distribution post operatively
    - Significant decrease of adipose tissue over time
    - Half life of 15.4 months
    - Outcome not influenced by degree of surviving fat
Obliteration
Cranialization

- Surgical approach is similar to obliteration
- Sinus exposure rarely requires osteotomies because of anterior table injury.
- Posterior table removed with elevators and rongeurs
- The posterior table may be used for anterior table reconstruction as long as mucosa is removed.
- Repair of the dura can be done with 5-0 nylon sutures, with complex injuries requiring debridement and pericranial flap.
Cranilization

- Donath Laryngoscope 2006,
  - 19 patients underwent pericranial flap with cranialization
  - One CSF leak post op with no infection
Treatment

- Devaiah, Larygoscope 2010
  - Antibiotic prophylaxis in the management of complex midface and frontal sinus trauma, N=220
  - No difference between in infections rates with use of antibiotics outside of periopertive time period
Follow up

- Close monitoring is key for any patient who has undergone repair or obliteration.
- Follow up every week for the first month, then monthly for the first year.
- CT should then be done annually to detect complications early.
- Long term follow up care is mandatory
Follow up

- **CT with soft tissue windows**
  - Range of normal appearance of Fat obliteration due to partial fibrosis of tissue and may be confused with air

- **MRI**
  - Fat has high intensity in T1.
  - Fibrotic areas are low intensity
  - Mucoceles have high T2 signal intensity, but may vary.
Complications

- Most common complications after surgery are
  - Frontal headaches 20%
  - Sinus infections 12%
  - Sinus fullness 11%
  - Sinus drainage 10%
  - Forehead depression 10%
Complications

- If conservative management failed for sinusitis treatment (antibiotics, oral and topical steroid, saline irrigations), then persistent outflow obstruction must be evaluated.

- Endoscopic surgical intervention to restore outflow should be pursued

- This should include a sinusotomy or a modified Lothrop.
Draf Procedures
- Type I - Removal of disease inferior to the frontal sinus ostium
- Type IIa – Removal of ethmoid cells projecting into the frontal sinus
- Type IIb – Removal of the frontal sinus floor from the lamina papyracea to the nasal septum
- Type III - Bilateral enlargement with removal of superior nasal septum and intersinus septum
Draf IIa (from septum to lamina papyracea)
Lothrop (Draf III)
Complications
Complications

Sivori, J Oral Maxillofac Surg 2010
- 43 patient over 6 yrs.
- 7 patient with complication of frontal pain, all obliterated sinuses

Protocol for Diagnostic Management of Chronic Pain
Chronic post-traumatic headache
Magnetic resonance imaging—evaluation of frontal sinus for pathologic features; temporomandibular joint, and cervical spine soft tissue injuries; neuroma formation in cases of possible nerve injury
Trigger point injections for cervical or masticatory myofascial pain—blockade of trigger point should eliminate pain
Neuropathic pain—blockade of nerve might eliminate pain; if neuroma identified, consider removal of neuroma; otherwise, treat with selective tricyclic antidepressants or selective anticonvulsants or, in select cases, with long-acting narcotics.
If pharmacologic management fails and pain can be eliminated by a local nerve block, an ablative procedure could be considered.
Chronic post-traumatic headaches and neuropathic pain might respond to tricyclic antidepressants or selective anticonvulsants, or both.
Frontal sinus fractures require a great deal of force and are consistent with multifacial trauma.

It is important to perform trauma evaluations on every patient with a thorough head and neck exam.

A good understanding of the frontal sinus anatomy and function is key for treating frontal sinus fractures.
Conclusion

- Although treatment is still somewhat controversial, following an algorithm for the treatment of sinus fractures is considered standard of practice.

- Therefore classification of the type and degree of fracture is important for treatment.

- Understanding of the treatments available (ORIF, obliteration, and cranilization) is also vital.

- New approaches for endoscopic surgery are possible as well.
References


References