Outline

- Etiology
- Associated injuries
- Management
- Fixation methods
- Sinus obliteration
- Cranialization
Frontal Sinus Anatomy Facts

- Absent @ birth
- Radiographically evident @ 8 years
- Adult size by 15 yrs
- 15% with unilateral sinus
- 4% with no sinus
- Anterior table 2-12 mm thick
- Posterior table 0.1 to 4.8 mm thick

Demographics/Etiology

- 5 - 12% of facial fractures
- 30 year old males
- 800 – 1600 ft lb to fracture

Demographics/Etiology

- High velocity impacts
- MVA 71% to 52%
  - 1974-86 to 1987-02
Demographics/Etiology

- MVA: 52%
- Assault: 26%
- Recreational Accidents: 9%
- Industrial Accidents: 5%

# Fracture Distribution

<table>
<thead>
<tr>
<th></th>
<th>Anterior</th>
<th>Posterior</th>
<th>Ant/Post</th>
<th>Frontal recess</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wallis et al</strong></td>
<td>1974-1986</td>
<td>13 (18%)</td>
<td>2 (3%)</td>
<td>55 (79%)</td>
<td>70</td>
</tr>
<tr>
<td><strong>Strong et al</strong></td>
<td>1987-2002</td>
<td>35 (28%)</td>
<td>4 (3%)</td>
<td>88 (69%)</td>
<td>127</td>
</tr>
<tr>
<td><strong>Gossman et al</strong></td>
<td>1990-2003</td>
<td>48 (50%)</td>
<td>0</td>
<td>48 (50%)</td>
<td>96</td>
</tr>
<tr>
<td><strong>Chen et al</strong></td>
<td>1994-2002</td>
<td>22 (28%)</td>
<td>0</td>
<td>56 (72%)</td>
<td>78</td>
</tr>
</tbody>
</table>
Associated injuries

- Loss of consciousness → 72%
- Obtunded/intubated → 21%
- Intracranial injuries
  - Pneumocephalus 26%
  - Cerebral contusion 18%
  - Dural tear 14%
  - CSF leak 11%
    - 5% with persistent CSF leaks
  - Epidural hematoma 8%

Other Facial Fractures

- Multiple facial fractures in 75% of pts.
- Pediatric frontal sinus fractures
  - 100% with concomitant orbital fractures

Table 4
Other maxillofacial fractures: type

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxilla</td>
<td>27 (32%)</td>
<td>52 (29%)</td>
<td>0.76</td>
</tr>
<tr>
<td>Zygoma</td>
<td>13 (16%)</td>
<td>19 (11%)</td>
<td>0.55</td>
</tr>
<tr>
<td>Naso-orbito-ethmoid</td>
<td>10 (12%)</td>
<td>40 (22%)</td>
<td>0.01</td>
</tr>
<tr>
<td>Nasal</td>
<td>8 (10%)</td>
<td>22 (12%)</td>
<td>0.30</td>
</tr>
<tr>
<td>Skull vault</td>
<td>8 (10%)</td>
<td>9 (5%)</td>
<td>0.30</td>
</tr>
<tr>
<td>Skull base</td>
<td>8 (10%)</td>
<td>19 (11%)</td>
<td>0.53</td>
</tr>
<tr>
<td>Mandible</td>
<td>8 (10%)</td>
<td>17 (10%)</td>
<td>0.8</td>
</tr>
<tr>
<td>Total fractures</td>
<td>82 (100%)</td>
<td>178 (100%)</td>
<td></td>
</tr>
</tbody>
</table>
Complications

**Major complications 5%**
- Meningitis
- Mucocele

**Minor complications 8%**
- Wound infections, frontal paresthesias, temporal nerve paresis, frontal bone irregularities, diplopia on upward gaze

CSF leak

- 12-30% basilar skull fx
- Spontaneous resolution 24-48 hrs
  - Temporal bone > Ant cranial fossa
- Sx’s
  - Postural headache
  - Bacterial meningitis
    - 7-30%

Management

- Weigh intervention risks in critical patients
- PE, CT scan
- Primary goal
  - Protect brain from further injury
- Secondary goals
  - +/- Sinus function
  - Cosmetic
- Anterior, Posterior, Nasofrontal duct, CSF leak
Anterior Table Management

- Non-displaced
  - Observation

- Displaced
  - ORIF (coronal, mid-brow approach)
  - Endoscopic vs open

- Comminuted fractures
  - ORIF (mesh vs miniplates)
  - Ensure no mucosa trapped between fragments

Posterior Table Management

- Separate nasal cavity/sinus from intracranial cavity
- CSF leak
  - No spontaneous resolution → explore
- Repair dural tears
- Sinus obliteration
- Severely comminuted
  - Cranialization

Nasofrontal Duct Management

- Obliteration

- Endoscopic Lothrop procedure

- Observation
  - Minor injury in a reliable patient
  - Reimage the patient in 1 to 3 months
<table>
<thead>
<tr>
<th></th>
<th>Anterior</th>
<th>Posterior</th>
<th>Ant/Post</th>
<th>Frontal recess</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gossman et al 1990-2003</td>
<td>48 (50%)</td>
<td>0</td>
<td>48 (50%)</td>
<td>??</td>
<td>96</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 7. Management of Frontal Sinus Fractures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>No surgical intervention</td>
</tr>
<tr>
<td>ORIF with sinus preservation</td>
</tr>
<tr>
<td>ORIF with sinus obliteration</td>
</tr>
<tr>
<td>Cranialization</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Anterior (%)</th>
<th>Anterior and Posterior (%)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (4.5)</td>
<td>5 (8.9)</td>
<td>6</td>
</tr>
<tr>
<td>18 (81.8)</td>
<td>22 (39.3)</td>
<td>40</td>
</tr>
<tr>
<td>3 (13.7)</td>
<td>15 (26.8)</td>
<td>18</td>
</tr>
<tr>
<td>0 (0)</td>
<td>14 (25)</td>
<td>14</td>
</tr>
<tr>
<td>22</td>
<td>56</td>
<td>78</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3. Spontaneous Resolution of Associated Cerebrospinal Fluid Leaks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Anterior table</td>
</tr>
<tr>
<td>Anterior and posterior tables</td>
</tr>
<tr>
<td>Posterior table displacement &lt;1 table</td>
</tr>
<tr>
<td>Posterior table displacement &gt;1 table</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Case</th>
<th>Spontaneous Resolution (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3 (100)</td>
</tr>
<tr>
<td>8</td>
<td>3 (37.5)</td>
</tr>
<tr>
<td>18</td>
<td>6 (33.3)</td>
</tr>
<tr>
<td>29</td>
<td>12 (41.4)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Wallis et al 1974-1986</th>
<th>1987-2002</th>
<th>Ant/Post</th>
<th>Frontal recess</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>13 (18%)</td>
<td>35 (28%)</td>
<td>55 (79%)</td>
<td>2</td>
<td>70</td>
</tr>
<tr>
<td>Posterior</td>
<td>2 (3%)</td>
<td>4 (3%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ant/Post</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frontal recess</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td>127</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7
Surgical repair

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranialization (%)</td>
<td>30 (41%)</td>
<td>27 (21%)</td>
<td>0.002</td>
</tr>
<tr>
<td>Osteoplastic flap and fat obliteration (%)</td>
<td>24 (33%)</td>
<td>92 (71%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Open reduction and internal fixation of anterior table (%)</td>
<td>14 (20%)</td>
<td>8 (6)</td>
<td>0.008</td>
</tr>
<tr>
<td>Ablation (%)</td>
<td>2 (5%)</td>
<td>0</td>
<td>0.12</td>
</tr>
<tr>
<td>Exploration only (%)</td>
<td>1 (1%)</td>
<td>3 (2)</td>
<td>1.0</td>
</tr>
<tr>
<td>Intersinus septectomy (%)</td>
<td>1 (1%)</td>
<td>0</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Endoscopic Repair

- Allows fixation of favorable ant table fxs
- Opportunity for nasofrontal aperture procedures at same setting.
Endoscopic Repair

- Fracture reduction
  - Endoscopic browlift (subperiosteal)
  - 30 degree scope w/endosheath
  - Central stab incision
  - Lateral incision to assist with the reduction

- Fracture camouflage
  - Old fractures
  - Alloplastic implant hides defect

Frontal Depressions

- Alloplastic fillers
- Acrylic implants
  - Commonly used
- Hydroxyapatite cement
  - Osseointegration
  - Good biocompatibility

Titanium Mesh

- Severely Comminuted fxs

Closed Reduction

- Case report
- Lost tip of probe in sinus

Obliteration History

- Dates back to 1950’s (Bergara)

- Hypothesis
  - Transplanted fat would remain vascularized
  - Non-viable fat would fibrose


Obliteration History

- Goodale and Montgomery (late 50’s and 60’s)
  - Fat obliteration → standard of care for difficult frontal sinus disease
  - No sx recurrence or radiographic recurrence after 5 years

- Hardy and Montgomery (1976)
  - 250 patients; median follow-up 8 years
  - Complication rate 18%
    - Abdominal wound - 5.2%
    - Acute postoperative infections (necrosis of implanted fat) - 3%
    - Recurrent chronic sinusitis - 3%
    - 4% of cases had to be revised
    - No report on the occurrence of mucoceles

Obliteration Indications

- Mucopyocele, or recurrent acute sinusitis
- Severe fractures
- Chronic sinusitis
- Tumor
Obliteration Principles

- Meticulous removal of all visible mucosa
- Removal of the inner cortex
- Cutting burr for thick bone and a diamond burr for the dura and orbital roof—periorbita
- Results do not depend on the choice of microscope or Loupe magnification
- Permanent occlusion of the nasofrontal duct
- Material that forms a fibrous barrier between the obliterated sinus and the nasal cavity.
  - Prevents the implanted material from sliding downward and impairs the ingrowth of nasal mucosa.

Obliteration Materials

- Adipose tissue
- Pericranium
- Hydroxyapatite
- Temporalis fascia
- Bone chips
- Bio glass
- Polytetrafluoroethylene carbon fiber
- Calcium sulfate methylmethacrylate
- Oxidized cellulose
- Gelfoam
- Lyophilized cartilage

Hydroxyapatite Obliteration

- **Friedman and Costantino (1991)**
  - HAC obliteration feline frontal sinuses.
  - 30% replacement of the HAC with bone at 12 months
  - 63% at 18 months.
  - There was no evidence of mucosal membrane ingrowth or mucocele formation
- **No complications in recent report in humans**

Pericranial Flap Obliteration

- Vascularized flap
- Does not rely on sinus walls for blood supply
- Low post op infection rate
- Bulky enough to obliterate frontal sinus
- Axial or random flap
  - Axial flaps
    - Anterior – supraorbital / supratrochlear arteries
    - Lateral - anterior division of superficial temporal artery

Fat Obliteration

- Outcome not influenced by degree of surviving fat.

- Post op fat distribution
  - < 20% → 53% of cases
  - > 60% → 18% of cases

- Statistical tests and modeling
  - Significant decrease of adipose tissue with time
  - Median half-life 15.4 mo

Post op scans

- CT
  - Soft tissue windows
    - Low attenuation of fat may be confused with air
  - Range of normal appearances ➔ stages of partial fibrosis of the obliterating fat.

Post op scans

- **MRI**
  - Fat
    - High signal intensity (T1)
    - Intermediate signal (T2)
  - Fibrotic areas
    - Low to intermediate signal (T1 and T2)
  - Patients with persistent symptoms had no distinguishing MRI features when compared with asymptomatic patients.

- **Appearance of mucoceles.**
  - Varies according to the protein concentration of the secretions
  - T1 - low, intermediate, or high signal
  - T2 - high signal intensity
Fig. 7. Sagittal MRI scans 12 months after fat obliteration of the frontal sinus. MRI shows surviving fat tissue as white areas in T1-weighted and black areas in fat-suppression scans. Left. T1-weighted image. Center. T2-weighted image. Right. Fat suppression.
Fig. 6. Mucocele of the frontal sinus 34 months after surgery.
A. Coronal magnetic resonance imaging (MRI), T2-weighted image.
B. Axial MRI, fat suppression.
Fat Obliteration

- Catalano → 59 patients (1 to 9 years post op)
  - 8.5% needed revision of osteoplastic flap
  - 6.7% required correction of frontal bossing
- Loevner → 13 patients (1 to 12 years post op)
  - 3 mucoceles
- Weber, Draf → 59 patients (1 to 12 post op)
  - Mucoceles
    - 5 of 51 cases
    - 1, 3, 4, 8 and 10 years

**TABLE II.**
Postoperative Complications After 1 to 12 Years in 59 Patients.

<table>
<thead>
<tr>
<th>Late Complications</th>
<th>N (%)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbness N V₁</td>
<td>5 (8.5%)</td>
<td></td>
</tr>
<tr>
<td>Mucocele</td>
<td>4 (6.8%)</td>
<td>11, 34, 49, 106, 130 months after surgery. One case with two recurrences of a mucocele and two revisions</td>
</tr>
<tr>
<td>Persistent pain without a mucocele or infection within the frontal sinus</td>
<td>2 (3.4%)</td>
<td></td>
</tr>
<tr>
<td>Frontal embossment</td>
<td>2 (3.4%)</td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td>4 (6.8%)</td>
<td>Revision with split calvarial bone in one case performed</td>
</tr>
<tr>
<td>Extrusion of ionomeric cement</td>
<td>2 (3.4%)</td>
<td>Revision with removal of ionomeric cement necessary</td>
</tr>
<tr>
<td>Insufficient esthetic result (patients’ view)</td>
<td>3 (5.1%)</td>
<td>Depression (2), hypertrophic scar after removal of ionomeric cement (1)</td>
</tr>
</tbody>
</table>
Pericranial Flap Cranialization

- Donald and Bernstein (1978)
  - First report of cranialization
  - By convention; frontal sinus left as dead space or filled with free adipose tissue.
  - Consider with displacement > one table width
  - Severely comminuted fx

  - 19 patients, no reported complications
  - One sphenoid CSF leak post op
  - No post op infections
What would you do?
References