



(Volume2, Issue9)

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# Frontal Bone Fracture Reconstruction: A Case Series

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## ABSTRACT

*Untreated depressed frontal bone fracture leads to secondary postoperative aesthetic problems. Minimally displaced anterior table fractures are observed, more displaced fractures are explored and reduced. Frontal sinus obliteration is done for fractures involving nasofrontal duct, whereas cranialization is done for anterior table fracture with CSF leakage or comminuted posterior table fractures. An existing laceration or a bi-coronal incision is used to gain access.*

**Keywords:** *Frontal bone fracture, Frontal sinus, anterior table, Posterior table, Nasofrontal duct etc.*

## 1. INTRODUCTION

The frontal sinus is the last of the paranasal sinuses to develop. It lightens the skull and cushions the brain from blunt forces and traumatic injuries. The frontal bone represents one of the strongest structures in the face [1]. Frontal sinus fractures account for 5% to 15% of all facial fractures [2] and are due to various high-velocity and low-velocity causes like motor vehicle accidents, gunshots, falls, and assaults [3]. The force required to fracture the frontal bones is 800-2200 lb. Injuries to the frontal sinus can be categorized into that involve the anterior table, the posterior table, the outflow tract, or a combination. Signs and symptoms of a frontal bone fracture include swelling of the soft tissues, contour irregularities, edema, hypoesthesia in the first trigeminal nerve distribution, anosmia from shearing of the adjacent cribriform plate, and intracranial injuries [4]. Neurosurgical consultations are mandatory if abnormal CT Brain studies are observed. Cosmetic outcomes and the correction of contour irregularities are treatment goals of isolated anterior table fractures [5]. If the posterior table is involved, the treatment goal is to separate the intracranial contents from the sinus, minimize the potential for intracranial complications such as cerebrospinal fluid (CSF) leaks, sinusitis, and intracranial infections. Radiographic imaging is the gold standard for diagnosis and classification. CT scan with fine cuts and reconstruction of the images in coronal and sagittal orientations aids in surgical planning. Early complications occur with the first 6 months of the injury. Late complications can occur decades after and may include bone erosion, mucoceles, mucopyoceles, and brain abscess.

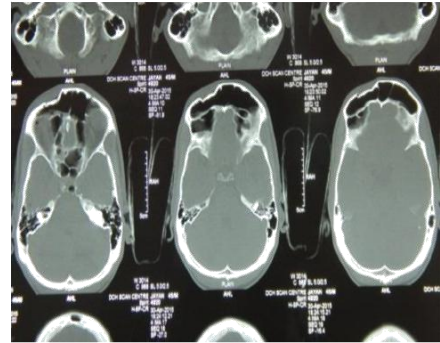
## 2. A CASE SERIES

**2.1 Case one :** A 34-year-old man was referred to our department from a local hospital with a history of RTA and depressed Rt frontal bone fracture two days old. At the time of RTA, he had a transient loss of consciousness

.There was no history of seizures or vomiting. At the time of presentation, the patient was fully conscious and oriented. Clinical examination revealed a noticeable depression on the Rt forehead, no evidence of paresthesia over the forehead skin. The pupils were equal and reactive, the visual acuity of both eyes was unchanged, and there was no evidence of diplopia. The orthoptic assessment revealed a slight restriction of the Rt eye secondary to soft tissue edema. There was no evidence of CSF leak. The neurosurgical consultation was done and there were no other intracranial injuries except the Rt frontal pneumocephalus for which the patient was kept under antiepileptics. Axial and coronal CT scan revealed a depressed fracture of the anterior wall of frontal bone. The posterior table was intact.



**Fig 1: Pre-op photo**



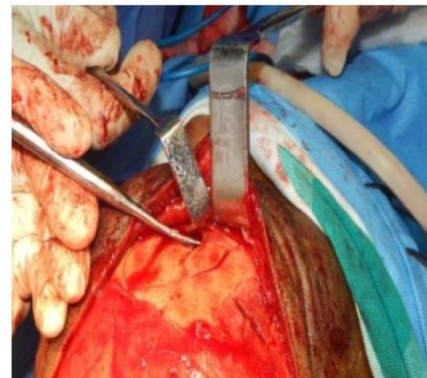
**Fig 2: Axial CT scan**

Pre-anesthetic checkup was done, neurosurgical fitness was obtained and the patient was posted under GA for the open reduction and fixation of the frontal bone fracture. **Surgical procedure.**

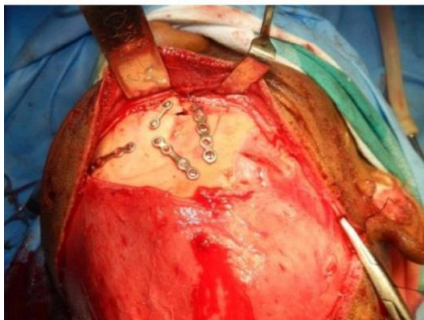
The patient was operated under GA. After proper scrubbing of operating field and draping, 2% lignocaine with 1:200000 adrenaline was infiltrated in the area to achieve vasoconstriction and to get fluid dissection. Bicoronal incision line marked, adrenaline saline infiltration done. The bicoronal flap was raised subperiosteally up to the level of fracture, followed by sub periosteal dissection. Comminuted fracture of the anterior wall of frontal sinus was noted. Fractured fragments were reduced and fixed using 2mm SS plates and screws. The mucosal lining of the sinus was removed.



**Fig 3: Surgical marking**



**Fig 4: Reduction of fracture**



**Fig 5: Fixation of fragments**



**Fig 6: Closure**

The patient recovered from anesthesia uneventfully. He received postoperative broad spectrum antibiotics for five days. He was kept on antiepileptic medication for one more week. The wound healed very well and there was no sign of infection or any other complication at the time of discharge. Staples removal was done on the fourteenth day postoperatively.

### **2.2 Case 2**

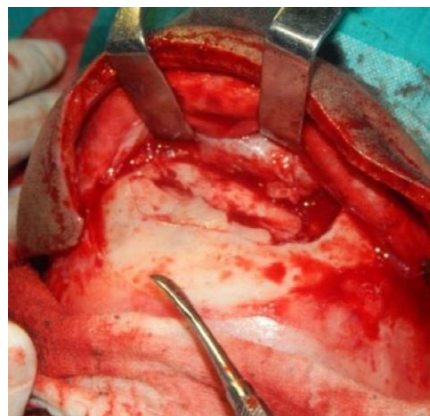
A 27-year-old male patient reported to the casualty with history of RTA. He had a history of loss of consciousness at the time of the accident. The patient was fully conscious and oriented at the time of presentation, there was no history of vomiting and seizures. Initially, edema was noted in the right frontal region. No clinical or radiographic evidence of head injury was present. Oedema subsided following 3-4 days a visible depression was evident in the right frontal region. CT scan also revealed a comminuted fracture of right frontal sinus anterior wall. There was no ophthalmic involvement. The patient was kept on antibiotics and antiepileptics. Neurosurgery fitness was obtained and the patient was operated under GA. The bicoronal flap was raised which revealed a comminuted fracture of the anterior wall of the frontal sinus, the fragments of bone was removed along with sinus lining and the defect reconstructed with titanium mesh.



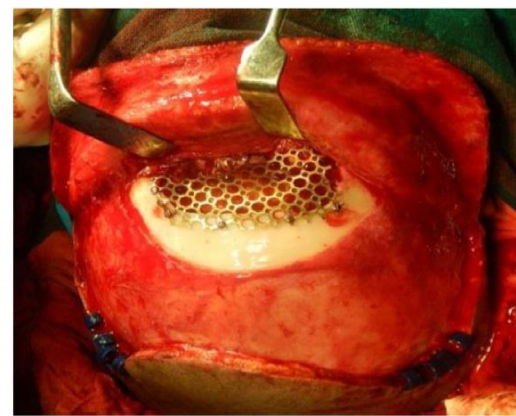
**Fig 6: Surgical marking**



**Fig 7: Raising bi-coronal flap**



**Fig 8: Comminuted fracture**



**Fig 9: Reconstruction with mesh**

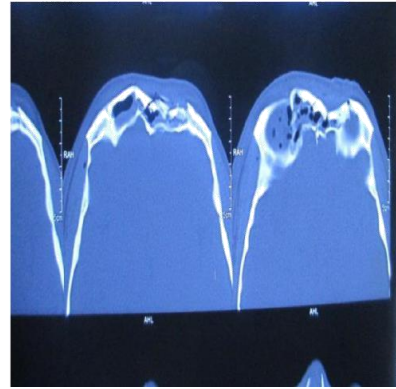
### **2.3. Case 3**

A 37-year-old male reported to the department with a depressed fracture of the frontal bone following an RTA. He had a history of loss of consciousness and vomiting and was initially admitted in neurosurgery to rule out head injury. The patient was transferred to our department after one week when his neurological status was stable. He also had a patellar fracture of right knee and left tibia fracture. The patient was kept on antibiotics, analgesics, and antiepileptics. The ophthalmic evaluation was normal. Neurosurgical fitness for procedure was obtained





**Fig 10: pre op photo**



**Fig 11: Axial CT depressed #**

There was no obvious head injury except Rt frontal pneumocephalus. CT scan revealed a comminuted fracture of anterior and posterior table left frontal bone. The patient was posted under GA, open reduction and internal fixation of fracture with 1.5 mm SS plates and screws was done through existing laceration. Tibia and patellar fractures were managed by the orthopaedic department. Postoperative period was uneventful and the patient was discharged on 7 th post op day.



**Fig 12: ORIF**

#### **2.4 Case 4**

A 34-year old male reported to our department with a depressed fracture of frontal bone following RTA. He had a history of transient loss of consciousness for which he was kept under neuro observation. CT scan revealed a depressed fracture of the frontal bone. The patient was kept on antibiotics, analgesics, and antiepileptics, no obvious head injury was present. Ophthalmic assessment of patient was normal. No other associated injury was present. The patient was operated under GA after obtaining neuro surgery fitness. The bi-coronal flap was raised which revealed a comminuted fracture of the frontal bone. Open reduction and internal fixation of fracture fragments were done with SS wires. Postoperative period was uneventful and was discharged on 7 the post op day.

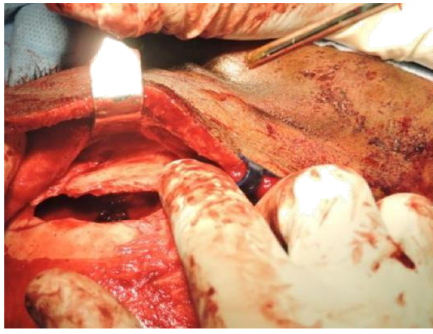


Fig 13: Reduction

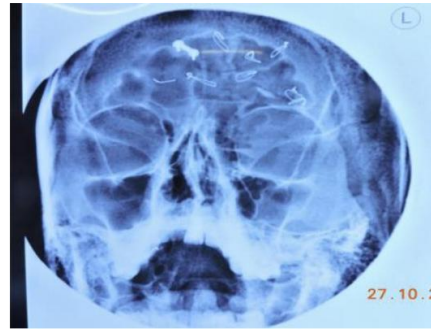


Fig 14: Post op x-ray

### 3. DISCUSSION

The frontal sinus develops as a cephalic evagination of the middle meatus and invades the frontal bone. The adult frontal sinus is 28 mm in height, 27 mm in width and 17 mm in depth and has several septae. The frontal sinus drains in the posteromedial wall on either side of septum .55% of frontal sinus drained directly into the frontal recess, 30% above the ethmoidal infundibulum, 1% above the ethmoid bulla [6]. The blood supply is from the diploic branch of the supraorbital artery and anterior ethmoidal artery. Venous drainage is through the angular and anterior facial veins externally and through posterior sinus wall via the foramen of Breschet.

The frontal sinus fracture represents 5-12 % of all facial fractures and are associated with neurological injuries like closed or open head injury, cerebral contusions, pneumocephalus, hematomas and dural tear. The incidence of CSF leak is 20%, maxillofacial and ophthalmic injuries are 66 % and 25% respectively [7]. A multidisciplinary team approach of maxillofacial surgeons, neurosurgeon, ophthalmologist, and otolaryngologist is a need for management. The most common type of frontal sinus fracture include combined anterior and posterior table injury 55-67% followed by isolated anterior table fracture 33-39% and isolated posterior table fracture in 6% of cases. A functioning sinus can be preserved in the majority of patients with frontal sinus fractures, regardless of the degree of displacement, depending on the status of the nasofrontal duct, the amount of posterior table comminution, and the presence of significant neurologic injury or dural embarrassment.

Each patient should be assessed as per Advanced Trauma life support guide lines and should have a regular neurological examination. The cornerstone of patient evaluation is a physical examination. Patients with forehead laceration or ecchymosis and hematoma of forehead, paresthesia in the distribution of supratrochlear and supra orbital nerves and visible depression, clear rhinorrhea or otorrhea, gross neurologic dysfunction, diplopia on upward or downward gaze, ptosis, subconjunctival ecchymosis, and air in the orbits should increase the suspicion of a frontal sinus injury. Holmgren et al identified specific soft tissue lacerations or injuries that were predictive of underlying frontal sinus fractures and used as a guide for determining the need for a facial CT scan [8]. Observe for any CSF leak that can present as clear fluid through nose or lacerations. A simple glucose dipstick test, halo test, beta -2-transferrin test for diagnosis of CSF leak. Imaging of choice is high-resolution CT scan.

The key element to successful management of patients with frontal sinus fractures is an understanding of frontal sinus drainage. The posteromedial position of the NFD makes it susceptible to injury [9]. The obstruction of the nasofrontal duct is a significant predisposing factor in the development of complications such as mucocele or mucopyocele formation and that this risk is life-long [10]. When frontal sinus drainage is impaired and mucus is retained, a mucocele may develop and act as an expanding tumor causing erosion of the bony walls of frontal sinus, orbits, and skull base. An anaerobic environment may subsequently develop, causing frontal sinusitis that may lead to osteomyelitis, meningitis, or brain abscess. Therefore, it is recommended that fractures involving the NFDs should be treated to create a "safe sinus" by complete sinus membrane removal and obliteration of the sinus cavity.

Sinus function is maintained by simply repairing the anterior table by stabilizing the bony fragments with titanium plates and screws or biodegradable fixation. Biodegradable plates and screws are ideal and provide a safe alternative to titanium fixation by virtue of favorable resorption profiles, and adequate strength in nonloaded areas [11]. Patients with displaced anterior tables, evidence of NFD obstruction and little or no posterior table involvement should have the frontal sinus obliterated. The biomaterials available for use in frontal sinus obliteration, including obliteration by spontaneous regeneration [12] autogenous grafts such as bone, muscle, and fat, and alloplastic such as methyl methacrylate [13], hydroxyapatite bone cement (BoneSource, Stryker Leibinger, Portage, MI; Mimex, Lorenz Surgical, Jacksonville, FL) [14], calcium phosphate bone cement (Norion, Synthes Maxillofacial) [15], and Glass ionomer (Abmin Technologies, Turku,

Finland)[16]. Autogenous abdominal fat is the well-studied and has the longest track record of success. Avoiding donor site morbidity is the motivation for the use of various alloplastic, bone substitute materials. Nondisplaced posterior table fractures or surgically reduced posterior table fractures healed by bony union. The dura either healed or was attached to the fibrous connective tissue at the healed fracture site.

Patients with significant posterior table involvement, dural lacerations, persistent CSF leak and/or brain injury will benefit from cranialization. Many patients with significant posterior table displacement require neurosurgical intervention to inspect and repair dura, evacuate hematomas, and debride brain tissue. A formal craniotomy is required in patients with rudimentary sinuses, through and through or penetrating injuries or those with massive brain injury. Often the frontal sinus cranialization can be performed via existing frontal bone fractures or through the posterior sinus wall. A long, anteriorly based pericranial flap should be developed at the time of the coronal approach for later use to line the skull base and plug the nasofrontal recess [17]. Meticulous attention to the removal of all sinus mucosa is critical, as is debridement of foreign material or devitalized tissue. If the brain injury is so severe then perform decompressive craniectomy that involves the frontal sinus, the sinus membrane should be removed, a peripheral mastectomy performed, and the frontal bone reconstructed at a later date.

#### **4. CONCLUSION**

Esthetic correction of depressed frontal bone is important to avoid contour deformities. In all our cases the anterior table fractures were reduced and fixed using wires, stainless steel plates, and screws, titanium mesh etc. The mucosal lining of the sinus was removed in all cases. Neurosurgical assistance was obtained in all case. Timely surgical intervention and proper reconstruction of frontal bone fracture are necessary to maintain contour and function.

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