

Frontal Sinus Fracture: Pathophysiology, Management and Controversies- A Review

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Abstract:- Numerous treatment alternatives and algorithms have been proposed over the years; yet the definitive treatment option for the timing and reconstruction of frontal sinus fracture remains a dilemma for the operating surgeon. Sinusitis, meningitis, encephalitis and mucoceles are the associated life threatening complications. The primary goal is to provide a safe sinus while minimizing patient morbidity and to restore patient back to their pre-injury form and function as much as possible.

➤ Aim

The purpose of this review is to evaluate the biomechanics, diagnosis, decision making and treatment options for the immediate and delayed treatment of frontal sinus fracture and to investigate the complications associated.

➤ Result

The best treatment of frontal sinus is debatable because of varied causes and sites of injury. The complications and the symptoms may take several years to develop as it may involve multiple intracranial structures with severe consequences however greater understanding and developments have significantly improved the functional and cosmetic results with a careful treatment planning and long term mandatory follow-up.

Keywords:- Frontal sinus, Fracture, Reconstruction, Immediate, Delayed, Complications.

I. INTRODUCTION

Frontal sinus gets pneumatized in the 4th week of intrauterine life. At birth it is usually absent, by 1 year the ethmoidal cells start to invade and form the frontal bone. By 5 years of age the sinus begins to expand and reaches full maturity by 15 years of age where the growth is complete with fully formed anterior (thick) and posterior (thin) chambers with irregularly shaped scalloped margins (Figure 1).

➤ Associated intracranial structures

Skull base attributes to the posterior aspect of the frontal sinus which is formed by the cribriform plate. The orbital roof corresponds with the anterior ethmoidal air cells, posterior table with the anterior cranial fossa and the anterior table form the facial contour. The frontal sinus drains through a small tract into the nasal cavity and along the ethmoidal sinus. The hour-glass shaped duct has a true ostium and infundibulum (Figure 2 and 3).

II. INCIDENCE

Frontal sinus comprises of 5-15% of the maxillofacial injuries. 43-33% of these fractures are isolated anterior table fracture, 67-49% are combined type (anterior table, posterior table and the nasofrontal recess), 5-7% (rarest) occur in posterior table, 58% occur in association with nasoethmoidal and facial trauma, 17% occurs with zygomaticomaxillary complex and 27.5% occur in combination with orbital trauma.

➤ Mechanism and Pathophysiology of injury

Frontal sinus injuries may result from blunt/ penetrating forces or high velocity impact. The midface is composed of paired vertical and transverse buttress which protects the sinuses on either side. The buttresses are resistant to functional forces surrounding the organs which form the facial contour. Thus, according to a “Crumple Zone” theory, the buttresses collapse after suffering an impact and prevent the sinuses. This effect resembles the “Bellchanger Effect”.

➤ Classification of frontal sinus fracture

Numerous classifications exist for frontal sinus fractures but Gonty’s classification is based upon location and extent of the fracture and is easier for diagnosis and treatment planning (Table 1).

➤ Diagnosis²

The diagnosis and evaluation of frontal sinus injuries should be done clinically and radiographically. The following criteria confirm the presence of a frontal sinus fracture:

- Clinical- forehead lacerations and abrasions, irregularities in the facial contour (depression/ concavity), tenderness, parasthesia, hematoma, watery rhinorrhea or salty tasting posterior nasal drainage (CSF leak- Halo test or β -Transferrin can be performed to confirm).
- Radiographic- Axial, Coronal and Saggital CT scans serve as a ‘gold standard’ for diagnosing frontal sinus. Axial view helps in viewing anterior and posterior table fracture, Coronal section helps in viewing the sinus floor and the orbital roof and Saggital section helps to determine the patency of frontal recess and 3D reconstruction for external contour.

III. CONTROVERSIAL TOPICS TIMING OF SURGERY AND TREATMENT OF FRONTAL SINUS FRACTURE

A. Timing of surgery

Treatment of frontal sinus fracture is so controversial that the indications, timing, treatment options and follow up vary in surgical specialities. In the past treatment for frontal sinus fractures was delayed until intracranial injuries were taken care of but the recent protocol indicates early and total repair of facial injuries¹¹⁻¹⁷ as more than 2 week delay of maxillofacial surgical intervention after trauma causes reconstruction difficulties and alters the patient’s aesthetic restoration and in a few cases the functional restoration poses a great challenge and may be complex¹⁸⁻²⁰. A delay of around 14 days causes soft tissues to become more adherent and difficult to repair. Sometimes, the treatment is delayed due to unavoidable neurologic complications and swelling. Therefore, the approach should be well balanced taking the overall condition of the patient into account¹⁵.

B. Treatment protocol

The aim of frontal sinus management is to create a “safe sinus” and restore the patient back to its pre-injury form and function as much as possible³. The most appropriate treatment strategy can be determined by assessing five anatomic parameters-

- Frontal recess
- Anterior table integrity (Figure 3, 4, 5 and 6)
- Posterior table integrity (Figure 7.a, 7.b, 8 and 9)
- Dural tear with/ without CSF leak
- Displaced/comminuted fracture.

This can be categorised into –Sinus obliteration, Cranialisation and Re-establishment of anatomy and drainage². The most commonly used surgical approaches are the existing laceration/scar, lateral brow incision/ brow lifting incision and coronal incision. Treatment options can be categorised in-

- Observation
- Open reduction and internal fixation
- Obliteration
- Cranialization
- Ablation
- Long term follow up and evaluation

IV. COMPLICATIONS

Fractures associated with the frontal sinus could develop functional or aesthetic problems and also more dangerous complications such as risk of infections and abscesses²²⁻²³. These complications make be divided into early and late complications (Table 2).

V. SUMMARY

The management and surveillance of frontal sinus injuries remain disputable among several specialities. The choice for treating frontal sinus fractures depends on the complexity of the fracture. If there is excessive comminution, dislocation of the posterior wall, a cranial trauma, an immediate reconstruction would not be the ideal choice. To choose the appropriate treatment we need an accurate diagnosis, focusing on the physical examination and data from computed tomography scans. Care needs to be taken since most complications result from incorrect indication for reconstruction. The authors believe that early intervention to create ‘safe sinus’ is the key, as these injuries have lower incidences and lack good clinical data supporting delayed treatments. With early diagnosis and intervention, life threatening complications can be eliminated. Anterior table fractures should be treated as immediately as posterior table fractures as not only does it alter the patient’s aesthetic but also may develop severe complications like encephalitis, meningitis, brain abscess and fronto-nasal duct obliteration which may take years to develop which may remain un-noticed for decades.

Serial number	Type	Classification	Sub-classification
1	Type I	Fracture of anterior wall of frontal sinus.	<ul style="list-style-type: none"> • Isolated anterior table. • Accompanied with supraorbital rim fracture. • Accompanied with nasoethmoidal complex fracture.
2	Type II	Anterior and Posterior table fracture.	<ul style="list-style-type: none"> • Liner fractures (Transverse and Vertical). • Comminuted fractures (Involving both tables or involving nasoethmoidal complex).
3	Type III	Posterior table fracture.	-
4	Type IV- ‘through and through fracture’.	Severely comminuted fractures of the frontal bone, orbit, nasal base and ethmoidal complex.	-

Table 1. Gonty’s classification of frontal sinus fracture.

Serial number	Early (within 6 months of fracture).	Late (after 6 months of fracture).
1	Frontal sinusitis	Mucocele
2	Meningitis	Brain abscess
3	CSF leak and fistulae	Facial deformity (due to delayed/improper intervention).
4	Diplopia/ damage to supraorbital or supratrochlear nerve.	Blindness
5	Intracranial abscess	Meningitis
6	Empyema	Localised osteomyelitis
7	Cavernous sinus thrombosis.	Chronic headaches

Table 2. Complications of frontal sinus fractures.

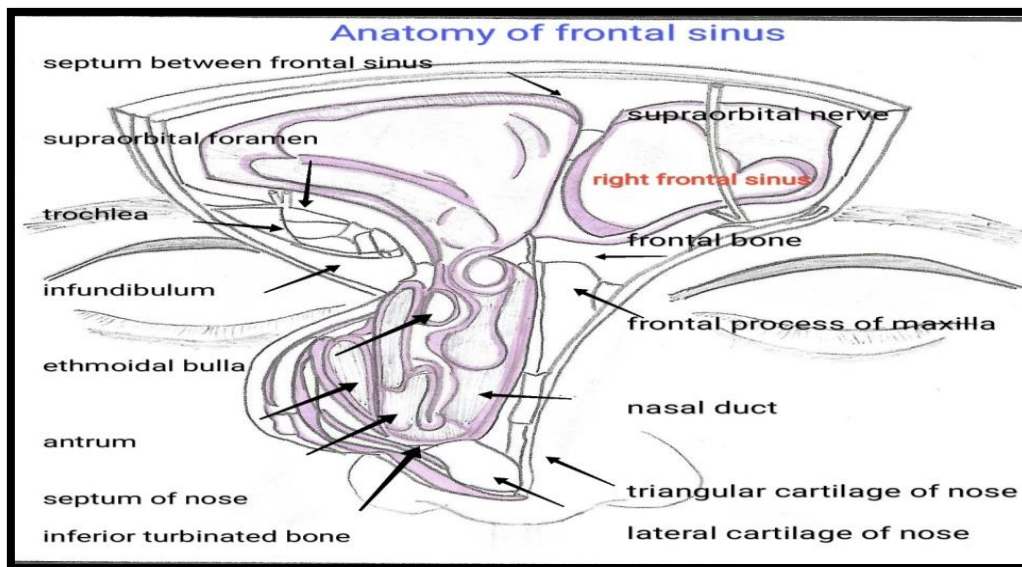


Fig 1:- Anatomy of frontal sinus

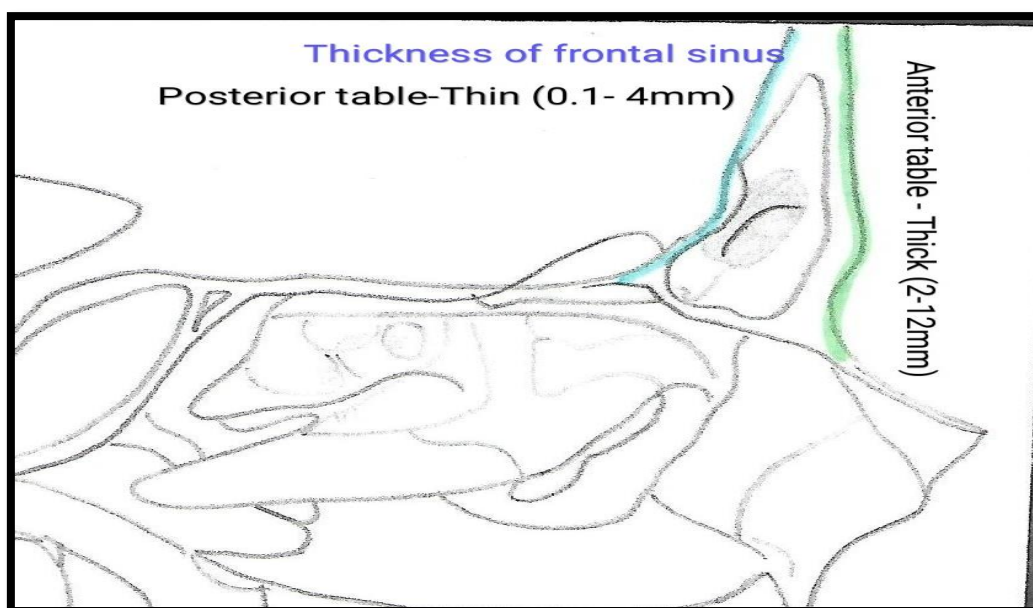


Fig 2:- Thickness of frontal sinus.

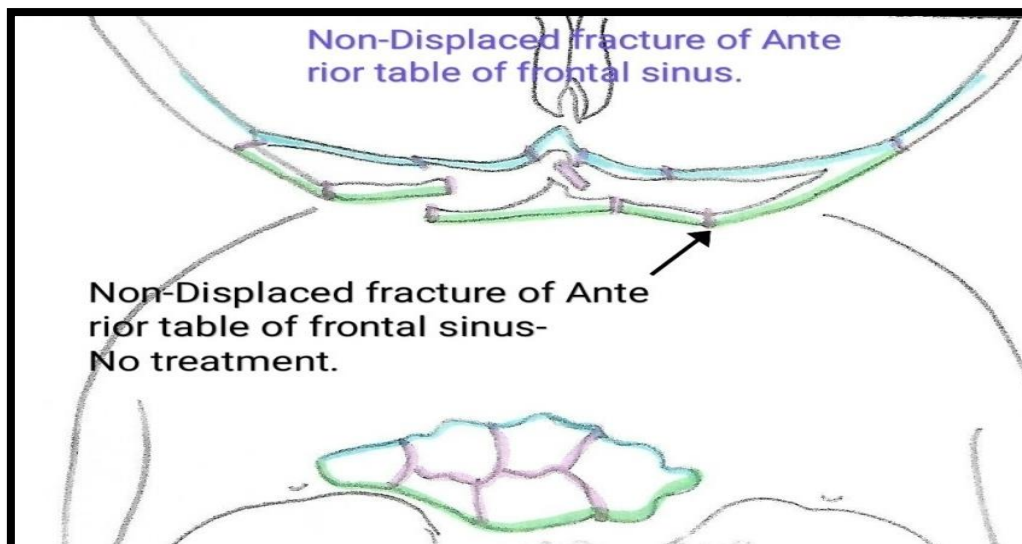


Fig 3:- Non- Displaced fracture of the anterior table of frontal sinus.

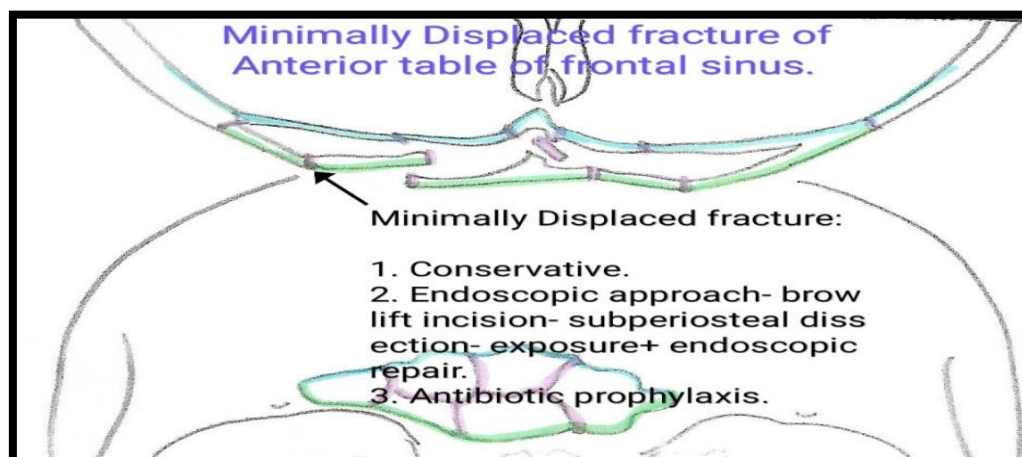


Fig 4:- Displaced fracture of the anterior table of frontal sinus

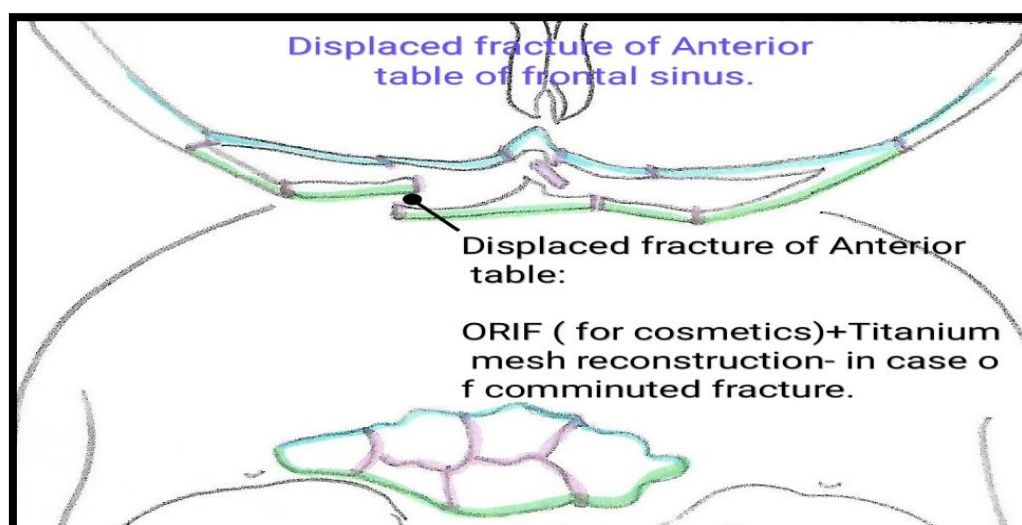


Fig 5:- Displaced fracture of anterior table of frontal sinus.

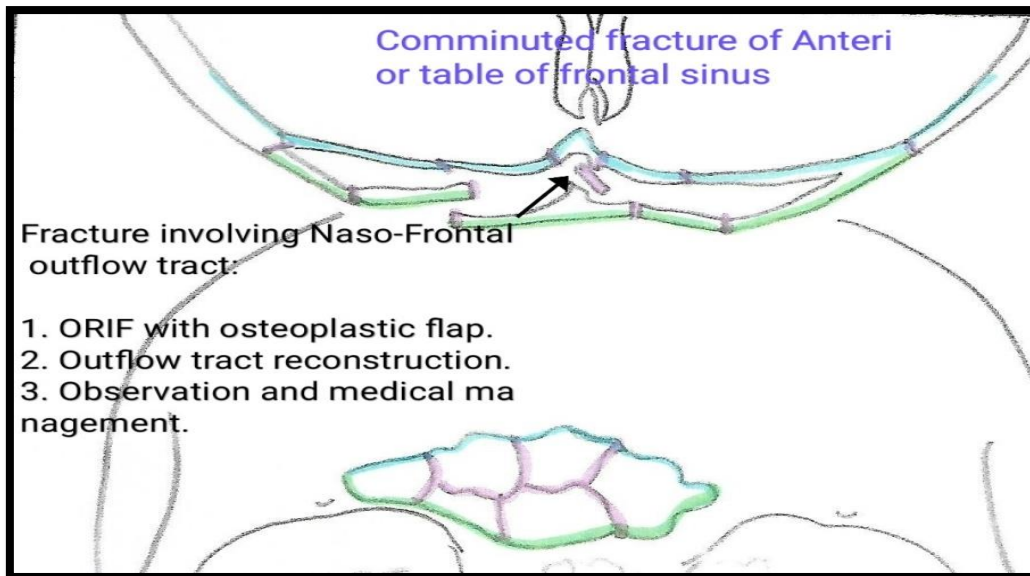


Fig 6:- Communitated fracture of anterior table of frontal sinus.

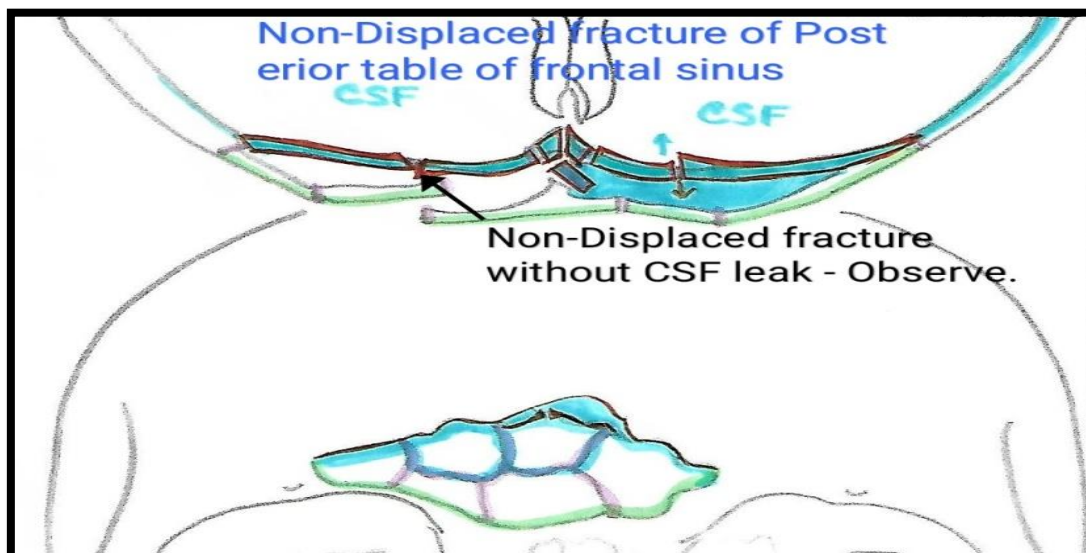


Fig 7.a:- Non- Displaced (without CSF leak) fracture of posterior table of frontal sinus.

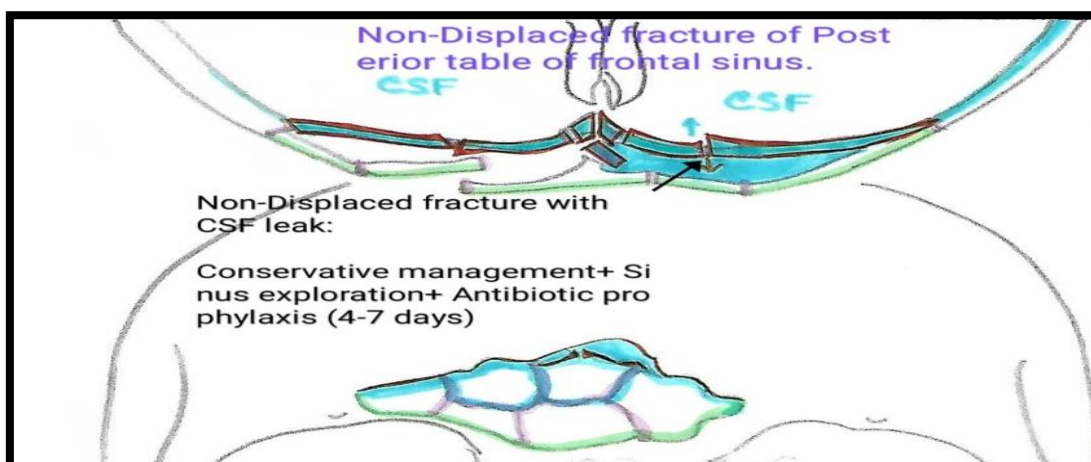


Fig 7.b:- Non- Displaced (with CSF leak) fracture of posterior table of frontal sinus.

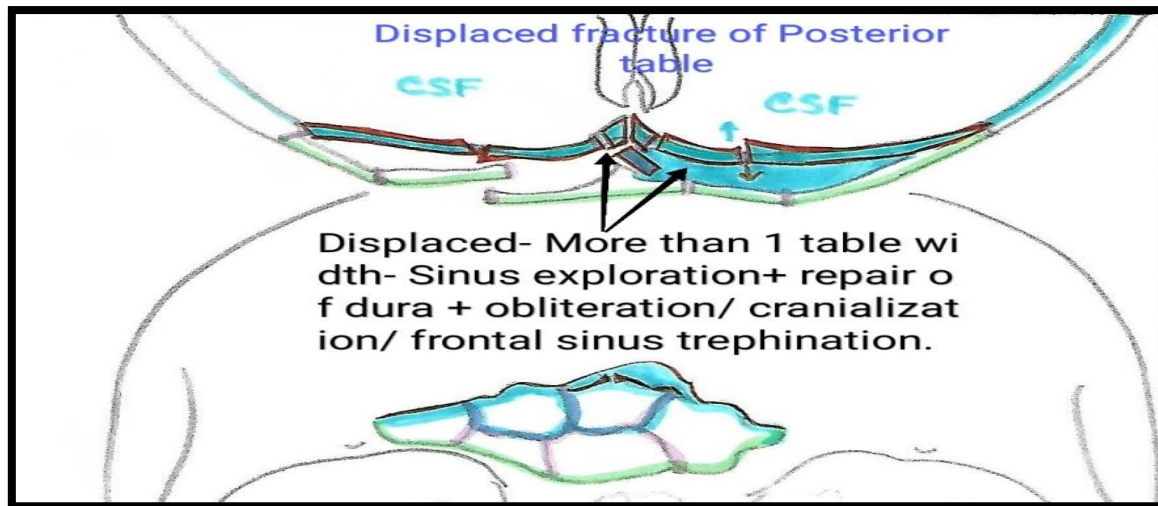


Fig 8:- Displaced fracture of posterior table.

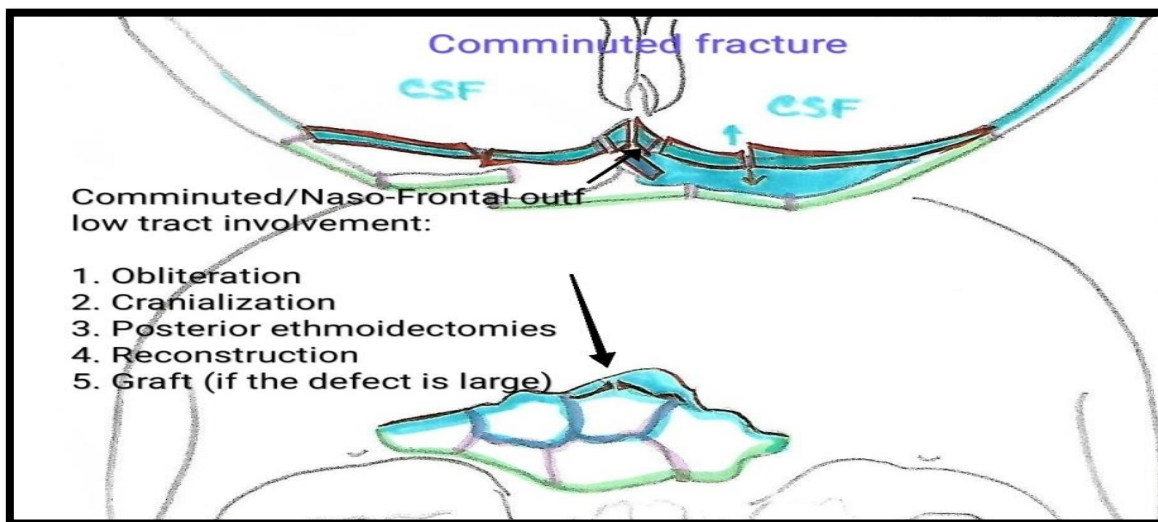


Fig 9:- Comminuted fracture of posterior table.

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