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# Anterior skull base fractures: A Narrative Review

Ahmad Hasan AlTurkstani[1*], Rami Ibrahim Alamri[2], Sameer Mohammad Al Mohmodi[3], Thuraya Ahmad Rumbo[4], Mohammed Ahmed omar Almahmudi[5], Mohammad abdulrahman hassan faiyadhah[6], Hamad Nasser Alshareef[7], Motaz Hussain Alsamli[8]

[1]Registrar-Preventive Medicine and Public health, Ministry of Health, Makkah, Saudi Arabia.
[2]Health and hospital administration, Ministry of Health, Makkah, Saudi Arabia.
[3]Registrar- Public health- Epidemiology, Ministry of Health, Makkah, Saudi Arabia.
[4]Registrar-Family Medicine, Ministry of Health, Makkah, Saudi Arabia.
[5]Health and hospital administration, Ministry of Health, Makkah, Saudi Arabia.
[6]General physician, Ministry of Health, Makkah, Saudi Arabia.
[7]Nursing technician, Ministry of Health, Makkah, Saudi Arabia.
[8]Nursing technician, Ministry of Health, Makkah, Saudi Arabia.
*Email: dr.aht@hotmail.com

**Abstract:** In this review, we tried to explain the point of difficulty in managing anterior skull base fracture. We discussed the anatomy, radiographic evaluation and management clues for every type in limited lines. There is a huge area of variation in management protocols. However, anterior skull base fractures should be treated aggressively. Treatment strategies are based on extensive knowledge of anatomy and radiology as well as practicing in a multidisciplinary team.

**[**Ahmad Hasan AlTurkstani, Rami Ibrahim Alamri, Sameer Mohammad Al Mohmodi, Thuraya Ahmad Rumbo, Mohammed Ahmed omar Almahmudi, Mohammad abdulrahman hassan faiyadhah, Hamad Nasser Alshareef, Motaz Hussain Alsamli. **Anterior skull base fractures: A Narrative Review.** *Nat Sci* 2020;18(8):34-38]. ISSN 1545-0740 (print); ISSN 2375-7167 (online). http://www.sciencepub.net/nature. 4. doi:10.7537/marsnsj180920.04.

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## 1. Introduction

Unique anatomical configuration of anterior skull cranial fossa gives it the morbid status of management (1). Blunt injuries are the most common type while penetrating injuries are rare and results in multiple variations of management according to the structure involved (2).

Previously, clinical examination and plain radiographs are the sole required issues for deciding for patients with anterior skull base fracture (ASBF) (3). Nowadays, computed tomography is the golden standard in the decision-making process.

## Anatomic

The complexity of anatomy is reflected in evaluation and treatment strategies (4). Orbit, sinonasal structures and anterior cranial fossa are close and one should evaluate each term during the assessment. Though, orbital structures, medial canthal ligament are important to be considered. They attached three areas; 1) posterior lacrimal crest; 2) anterior lacrimal crest and 3) the nasal process of the maxilla (5). All these structures are surrounding the lacrimal sac. The latter is lateral to anterior ethmoid air cells. The ethmoidal and frontal cells are close in proximity. They are connected by frontal recess area which if obstructed, late complications may complicate a patient's scenario (6). The central part of anterior cranial fossa lies posterior or frontal sinus and cribriform plate as well as the fossa ethmoidalis. Further posterior direction to the above-mentioned structure, lies the planum sphenoidalis which is the roof of the sphenoid sinus and sella. The orbital roof lies at the lateral part of the anterior cranial fossa (ACF) (7). Therefore, a fracture to this area should be kept in mind the proximity of the structures above mentioned. More details are illustrated in Rhoton works.

The thickness of the bones exposed to trauma, dural adhesions and force applied are important factors. Orbital roof, floor, ethmoidal cells, lacrimal bones, posterior frontal sinus table and lamina papyracea are all regarded as thin-walled structures (5). This function facilitates easy fragility upon exposure to mild-moderate trauma and produces a significant subluxation. Anterior table of the frontal sinus, as well as medial part of it, are also thin-walled and a moderate blunt trauma can break it (8).

At the ACF, dense dural attachments are found evenly distributed bilaterally. So, CSF leak, contusion and pneumocephalus may emerge at the short or remote onset (9).

The frontal sinus mucosa is an important factor to be considered. It is continuous with ethmoid air cells mucosa through foramina. These foramina can facilitate infection spread after the incidence of trauma (10).

**Evaluation**

General evaluation of a polytrauma patient should be processed before any local evaluation either for skull base or any other region. A patient with anterior skull base fractures should be evaluated thereafter by a harmonic team of neurosurgeons, ENT surgeons, ophthalmologists and maxillofacial surgeons. Clinical examination is aided by careful radiographic evaluation. Neurologic examination (especially cranial nerve functions) is mandatory to be considered (11).

Medicolegally, CSF leakage must be ruled out at any stage of presentation. Extraocular structures, globe motility and eye should be assessed well. Telecanthus should be ruled out by performing adjunctive clinical measurements (12).

Palpation of orbital rims and nasoorbital regions is also a primary concern. Oedema and ecchymosis may mask significant fractures. Bimanual examination of bony area stability of medial canthal tendon is described by Paskert and Manson (13). This area which lies between superior piriform aperture and the medial orbital rim is called the central fragment.

**Fractures**

The complex nature of anterior skull base anatomy renders its fractures complex and decision wised rather than technically demanding. Fractures in the nose-orbit-ethmoid region are associated with central ACF fractures (14). Diagnosis of later part involvement needs meticulous clinical and radiological evaluation. No exact percentage of involvement known till this moment. If one considers CSF leakage as a sign of involvement; around 40% of naso-orbito-ethmoidal fractures are associated with ACF fractures (15). Although, CSF leakage is not the sole presentation (i.e. the percentage might be higher). Unfortunately, classification systems ignored the skull base involvement like Markowitz-Manson classification for canthal tendon abnormalities. Raveh classification system (16) and Gruss (17) also missed skull base involvement (18).

Frontal sinus fractures are commonly associated with ASBF especially posterior table of the frontal sinus. Leakage of CSF is pathognomonic (but not sole) for skull base fracture (6,19).

All classification systems deal with frontal sinus fracture discussed the integrity of three elements:

1) Anterior frontal sinus wall
2) Posterior frontal sinus wall
3) Frontal recess area

Extensive anterior table fractures induce injury to naso-orbito-ethmoidal complex and frontal recess area as well (9,20). Posterior table fractures are associated with an intracranial injury which requires cranialization by a pericranial flap (21) or endoscopic skull base repair even both.

Skull base injury is merely mentioned in regional facial fractures' classifications. They used to be treated simply apart from regional fractures (8).

Skull base fractures can be categorized into medial and lateral parts. Medial type involves frontal, ethmoid sinuses and naso-orbito-ethmoidal fractures (22). Lateral forms included frontal bone, supraorbital ridge and orbital roof. Other added "posterior" form which includes fractures to the bony structures posterior to the inner table of frontal sinus down to planum sphenoidal (20).

Aggressive injuries required an aggressive strategy for management. Recurrent or persistent CSF leakage required intracranial exploration (23) or endoscopic repair.

Sphenoid bone fractures gained no popular term in the scientific literature. Few literatures address this term and tried to correlate fracture type and mode of fracture and associated injuries. Sphenoid sinus effusion on CT brain is a pathognomonic sign of skull base fracture. Sphenoid wing fractures harbour orbital, neural and vascular injury due to its complex anatomical arrangement (superior and inferior orbital fissures) (9,24).

Sellar region fractures are associated with risks of carotid artery injury. The incidence is low, but subarachnoid haemorrhage can occur secondary to the impact of power exerted by the blunt injurious instrument not directly by the carotid artery (12).

Pseudoaneurysm can also happen which may manifest as persistent epistaxis. Diabetes insipidus and CSF leakage can occur secondary to sellar floor fracture (25).

All data mentioned above are about the blunt injury. Stab and projectile wounds are rare and difficult to be treated (3).

The anatomical variations in pediatric skull base fractures needed to be illustrated here. Most of these fractures are blunt injuries (fall from high and motor or car accident). Orbital roof fractures are common at this age (before age of 7 years). This can be attributed to lack of pneumotization of frontal sinuses (1,5). Whatever strategy followed, facial regrowth impairment is the major issue following these injuries.

**Approach**

Bicoronal incision is the standard approach for repairing ASBF. This approach provides the most valuable and useful approach for surgeons. Its beneficial role is matchless. Besides it's a straightforward approach, skin incision is easily covered beyond hairline. Frontal craniotomy with subcranial approach is achieved by this approach. Other approaches are specific for certain type of injuries like midfacial degloving approach. Open-sky approach and Lynch incision are good alternatives for naso-orbito-ethmoid fractures. Also, endoscopic approach can give a convenient option in specific type of fractures witch had lower risk for intra cranial complications and bitter to avoid any scar.

**Reconstruction**

Certain doctrines are existed in the management of anterior skull base fractures. Tissue debridement (brain and bone) is a vital step prior to dead space replacement (24). Extensive bone lost is best bridged by bone graft. Extensive comminution may be an obstacle against plating. This type of bone loss is seen frequently in thin-walled bones. Orbital roof fracture should be reconstructed to prevent enophthalmos or frontal lobe herniation into orbit (7). Sources of bone grafts are either calvarial bone, iliac crest or rib. Dural repair must be accomplished in a watertight fashion. This repair may be achieved by direct suturing or using a synthetic material. The principle of management of sinonasal region fractures is to separate it from intracranial content (9). The goal beside to aesthetic reconstruction is to prevent CSF leak. This may be done by a free flap or a vascularized flap. Frontal sinus cranialization is defined as complete removal of posterior wall with mucosa and plugging the frontal recess area with soft tissue. The rest of the sinus room may be filled with abdominal fat or pericranial flap (26).

Table 1 summarizes the indications of reconstruction. These indications are straightforward causes. It is not logical to operate unstable patient or who have poor Glasgow outcome scale.

Table 1: Factors Influencing Anterior Skull Base Fracture Management (20)

| Anterior Skull Base Fracture Management |
|---|
| Relative Operative Indications* |
| Intracranial hematoma |
| Significant mass effect |
| Uncontrolled intracranial pressure elevation |
| Brain shift with impending herniation |
| Infection |
| Empyema |
| Abscess |
| Cerebrospinal fluid leak |
| Persistent |
| Recurrent |
| Fracture displacement |
| 7 mm or greater |
| With compound fracture |
| With brain laceration |
| With extensive dural tears |
| With cosmetic deformity |
| Causing neurologic deficit |
| Causing optic nerve compression with visual loss |
| *Indications modified according to severity of patients overall condition and associated injuries. |
| *Indications modified according to severity of patients overall |

**Conclusion**

Anterior skull base fractures should be treated aggressively. Treatment strategies are based on extensive knowledge of anatomy and radiology as well as practicing in a multidisciplinary team.

**Conflict of interest**

There was no conflict of interest

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