This lecture is an overview of maxillary fractures. Maxillary fractures are often encountered by the Otolaryngologist when evaluating patients with facial trauma. These fractures also serve as a source of frequent test questions on both the Otolaryngology in-service and board exams. The primary goal of this lecture is to provide a basic overview of maxillary fractures, with particular attention to the anatomy, physical exam findings, and management. I will also cover frequent test topics that are relevant, and these will be in **bold**. I hope this lecture serves as a basis to inform any Otolaryngologist in training of how to approach these patients and how to appropriately diagnose, manage, and treat them. The focus of this talk is **not** to provide details on the surgical interventions, but rather to provide a general overview. The outline of this talk is as such:

**OUTLINE**

- Introduction
- Anatomy
- History and physical exam
- Imaging
- Non surgical treatment
- Surgery

**INTRODUCTION:**

The maxilla is a vital bone of the midface that:

1. Forms the roof of the mouth
2. Houses the upper teeth
3. Forms part of the wall of the orbits
Maxillary Fractures  

4. Forms the floor and lateral wall of the nasal anstrum

The maxilla absorbs energy with impact, thus protecting the orbits, intracranial contents, and nose. Maxillary fractures usually result from blunt trauma such as from a baseball bat to the face or a car crash. A key point in surgical management is that accurate repositioning of fractured skeletal fragments is crucial for both function and aesthetics. Overall, maxillary fractures can range from a simple Le Fort I fracture to a complex and challenging comminuted fracture that falls within multiple Le Fort classifications.

ANATOMY

Bony anatomy

There are eight bones that normally articulate with the maxilla. These are the frontal, ethmoid, nasal, zygomatic, lacrimal, inferior nasal concha, palatine, and the vomer (Slide 4). The maxilla is composed of two halves that fuse at the intermaxillary suture line. There are four processes of the maxilla which are the zygomatic, frontal, alveolar, and palatine processes (refer to Slide 5). The maxilla forms the major portion of the floor of the orbit. This is particularly important because if a maxillary fracture causes ocular issues such as entrapment, then surgical intervention may be mandated.

There are many canals and fissures in the orbit. The lacrimal canal houses the lacrimal sac and duct. The inferior orbital fissure contains a few blood vessels and a branch of V2 but is overall of lesser importance. The superior orbital fissure is extremely important and contains CN III, IV, VI, and V1 of CN V (also some vessels and sympathetic fibers from the cavernous plexus). When performing surgery the superior orbital fissure is a danger zone. The optic canal is adjacent to the superior orbital fissure and contains the optic nerve, thus the optic canal Is another danger zone.

Buttresses - vertical

There are several buttresses that serve as pillars of the midface. There are three main vertical buttresses and several horizontal buttresses. These help to identify key areas of fracture and stabilization of the midface as they relate to both function and aesthetics. The three main vertical buttresses are:
1. **Nasomaxillary buttress (AKA medial buttress):** Most anterior buttress. It extends from the maxillary alveolar ridge along the pyriform aperture up to the medial side of the orbit, the frontal process of the maxilla, and to the superior orbital rim.

![Image of Nasomaxillary buttress]

2. **Zygomaticomaxillary buttress (AKA lateral buttress):** Bears the strongest load of the vertical buttresses. It starts above the 1st maxillary molar and extends to the zygomatic process of the frontal bone.

![Image of Zygomaticomaxillary buttress]

3. **Pterygomedial buttress:** Most posterior buttress. It extends along the alveolar ridge to the base of the skull. It is less important than the other vertical buttresses because it is less accessible surgically.

![Image of Pterygomedial buttress]

**Buttresses - horizontal**

Along with the vertical buttresses there are several horizontal beams or buttresses. The horizontal buttresses are weaker and less important structurally than the vertical buttresses; however, they serve to reinforce the vertical buttresses and provide width and projection to the face. There are several horizontal buttresses including the frontal bar (most important horizontal buttress), inferior orbital rim, maxillary alveolus and palate, zygomatic process, greater wing of the sphenoid, medial and lateral pterygoid plates, and the mandible. Overall, the key point to the buttress system is that it helps to identify areas of fracture and stabilization. If the buttresses, particularly the vertical buttresses, and not restored, then the midface can become shortened and “telescope” inwards.

**Le Fort Classifications**

Maxillary fractures are traditionally classified according to their “Le Fort classification.” Rene Le Fort was a French surgeon in the last 19th and early 20th century that specialized in pediatric and
orthopedic surgery. He created the three Le Fort classifications of midface fractures. He did his research via delivering blunt force to cadaver heads from various degrees of magnitude and from different directions. The legend is that he accomplished this by using cannon balls. The major advantage of the Le Fort classifications is that they help to stage the degree of severity of fractures. However, in reality midface fractures are often difficult to characterize. **There are three Le Fort fractures, all of which involve the pterygoid plates – this is important because the pterygoid plates form the bulk of the pterygomaxillary buttress, and if they are not restored there can be midface shortening and telescoping.** The three Le Fort classifications are:

1. **Le Fort I: Low maxillary fracture.**

   A Le Fort I fracture is usually caused by low anterior-posterior force. It involves the floor of the nose, the lower third of the maxilla, the palate, and the pterygoid plates. **A complete Le Fort I fracture causes the upper alveolus to become separated from the upper maxilla, thus resulting in a mobile palate.**

2. **Le Fort II: Pyramidal fracture.**

   This is usually caused by a superiorly directed force of and anterior-posterior force along the Frankfort plane. **The Frankfort plane is an imaginary horizontal line that defines the horizontal plane of the skull. It runs along the upper rim of the external auditory canal and the lower rim of the orbit.** A Le Fort II fracture occurs across the nasal bony superstructure, the frontal process of the maxilla, the anterior wall of the maxilla, and the orbital floor including the infraorbital foramen (which is important because it contains the V2 branch of CN V. This fracture also extends laterally to involve the pterygoid plate.

3. **Le Fort III: Craniofacial dysjunction.**
Le Fort III fractures are caused by high velocity injuries (i.e. MVC). The fracture extends laterally across the nasofrontal suture, orbital walls and floor, zygomaticofrontal suture, zygoma, and pterygoid plate. A complete Le Fort III fracture would result in a mobile zygoma on physical exam. I would like to jump ahead for a minute and discuss the management of Le Fort III fractures. These can be devastating injuries that involve cerebral trauma. Fracture repair may need to occur as a staged procedure with neurosurgery. Open reduction and internal fixation (ORIF) may need to be delayed until the patient is neurologically stable. Surgically, if complete craniofacial dysfunction has occurred, the maxilla must be fixed between two stable platforms: the cranium superiorly and the mandible inferiorly.

**HISTORY AND PHYSICAL EXAM**

For any trauma patient, the first step should be the **ABC’s**: airway, breathing, and circulation. As part of this process the neck should be immobilized in a cervical collar with the assumption that there may be an underlying cervical spine injury. Once the ABCs are managed and stable, a proper history and physical exam can be obtained. Trauma patients with facial fractures can often be difficult from which to elicit an accurate history. They may have associated intracranial, abdominal, or intrathoracic injuries. They may also be inebriated or under the influence of drugs such as cocaine, heroin, or benzodiazepines.

The physical exam should always begin with a full ENT exam. In addition a dental evaluation is crucial for determining the patient’s occlusion and looking for any chipped or missing teeth. The face should be palpated for bony crepitus, step offs, or a mobile palate or zygoma. The neuro exam is also important with attention to the cranial nerve exam. Finally, a thorough ophthalmic exam should be pursued, including an examination of extraocular movements, pupillary reflexes, visual acuity (i.e. Snellen chart), and a forced duction test.

**Forced duction test:** This is a test that is performed to determine if there is diminished or absent movement of the eye due to neurological or mechanical restriction. The anesthetized conjunctiva is grasped with forceps and the globe is moved in the direction of restricted movement. No passive movement means there is mechanical restriction. This test is rarely performed on awake patients as it is poorly tolerated. However, it is an excellent tool intraoperatively before and after ORIF to determine if there is mechanical restriction.

**Soft/bony tissue signs:** A few characteristic signs on exam include periorbital ecchymosis, massive tissues swelling, subconjunctival hemorrhage (particularly if the infraorbital rim is involved), subcutaneous emphysema, and bony crepitus of the midface. Bony crepitus is common in severely
comminuted fractures. A **clinical pearl is that bony crepitus of the midface is often a sign of ethmoid sinus fractures.**

**Diplopia:** Herniation of orbital soft tissues (orbital fat and inferior rectus muscle) into the maxillary sinus can cause diplopia or double vision. **If there is traction to the extraocular muscles or compression of the globe there can be a phenomenon known as the oculocardiac reflex. This can result in bradycardia, junctional rhythms, or asystole.** If you suspect an orbital floor injury, do a brief cardiac exam and check the patient’s vitals or cardiac monitor.

**Epiphora:** Fractures of the inferior medial orbital area may involve the lacrimal sac and duct.

In relationship to the globe, the lacrimal gland is located superolaterally and the lacrimal sac is located medially. Fractures in this area may disrupt the lacrimal sac or duct, thus leading to the inability of tears to drain into the nose, and thus resulting in epiphora or overflow of tears onto the face.

**Enophthalmos:** This is due to volume changes of the bony orbit relative to the globe and soft tissues. In this situation the globe becomes displaced posteriorly.

In the above picture, the patient’s right eye appears smaller and “sunken in.” This is **enophthalmos.**

**Amarurosis:** This is a partial or total vision loss that may occur if there is a fracture of the optic canal. This causes direct injury to the optic nerve. Slide 27 depicts a CT sinus coronal view (bone window) with a fracture of the right optic canal. **If a patient has progressive blindness in the presence of a fracture of the optic canal, then this patient should urgently be brought to the operating room for orbital decompression.**

**Nasal deformities:** Facial traumas may have obvious deformity of the external nose. Nasal obstruction is another common finding. This may be due to congestion or edema after the injury. It can also be due to derangement of the nasal bones and septal structures. Epistaxis may originate from the ostia of the maxillary or ethmoid sinuses, as well as from nasal cavity lacerations. **Nasal**
obstruction can also be caused by posterior inferior displacement of the maxillary segments by the pull of the medial pterygoid-masseter “sling.”

The medial pterygoid and masseter muscles are joined together by a tendon around the ramus of the mandible. This forms a “sling” that may pull any displaced maxillary segments down and backwards.

**Dental manifestations:** Displacement of the maxilla can also cause malocclusion. The most common abnormality that results is an “open-bite” deformity, depicted by the picture below. This again is caused by the pterygoid-masseter sling pulling the maxilla posteriorly and inferiorly, creating a gap between the upper and lower incisors.

Another less common abnormality is the dish face deformity. This results when someone receives a blow to the front of the midface, causing a “dished-in” appearance to the midface. The dishface deformity pushes the maxilla posteriorly, thus creating a Type III malocclusion scenario. For review, a **Type III malocclusion** is when the mesiobuccal cusp of the 1st upper molar is **posterior** to the buccal groove of the 1st lower molar.

**Airway:** **AIRWAY COMPROMISE IS THE #1 PRIORITY.** In many patients with extensive facial fractures, orotracheal intubation is a poor option due to poor visualization (i.e. from displaced bone fragments, blood, etc.) or the potential to aggravate an underlying cervical spine injury. Nasotracheal intubation is also a poor option due to the potential to accidentally pass the tube into the brain (i.e. if a cribiform plate fracture is present). A bedside emergency airway may need to be obtained via a cricothyroidotomy or slash tracheotomy. If able, a formal tracheostomy is preferred.

**CSF leak:** This results when a fracture extends through the cribiform plate or roof of the ethmoid sinuses (AKA fovea ethmoidalis). If present, the patient may have clear nasal discharge and report a salty taste in his or her mouth. Beta-2-transferrin is a test that can be used to determine if the fluid is CSF. Beta-2-transferrin is an isoform of transferrin that is highly specific to CSF. The downside of
this test is that it usually takes several days to receive the results, thus precluding this as a viable test in the acute setting.

Miscellaneous: These patient may have massive nasal or pharyngeal hemorrhages that go unnoticed if the patient is in the supine position. Also, if a patient has a disarticulated palate (i.e. complete Le Fort I fracture), it may be immobile if the midface is impacted. These patients would experience excruciating pain with biting down.

IMAGING

After the history and physical exam, the next step is imaging, assuming the patient is hemodynamically stable. As a rule, if a patient is hemodynamically unstable and rushed to the OR without imaging, the Otolaryngologist should perform a tracheostomy to secure the airway and place the patient in intermaxillary fixation. Fixation is crucial because by placing the patient in their pretrauma occlusion, it will stabilize any existing fractures and serve as the basis for a formal reconstruction at a later date. Xrays are now more historical as a means of imaging for facial fractures. CT has become the standard to delineate the extent and severity of midface fractures. Axial and coronal views are particularly helpful along with 3D reconstructions. The reason for CT becoming the standard is that it is fast, relatively inexpensive, and excellent for evaluation of bony structures. The downside is that it delivers a much higher dose of radiation compared to Xrays. This is a particularly important point to keep in mind with children. MRI has a limited benefit in the acute setting, primarily because it is expensive, time consuming, and better for evaluating soft tissue rather than bony structures. MRI is particularly useful for evaluating cerebral or optic nerve trauma.

NON SURGICAL TREATMENT

Prophylactic antibiotics are an area of controversy for patients with facial fractures. This applies to patients in both the preoperative and postoperative settings. To date, there are no large multicenter randomized control trials to address this issue. A recent literature review by Morris et. al in The Laryngoscope examined the use of prophylactic antibiotics for patients with either mandibular or non-mandibular facial fractures. They reviewed five studies that they determined had the highest level of evidence. They concluded from their review that there is not enough data to evaluate the efficacy of antibiotic use for non-mandibular fractures; however, there is evidence that preoperative antibiotics are beneficial for mandibular fractures. They also found evidence that post-operative antibiotics are not beneficial for either non-mandibular or mandibular fracture.

SURGERY

The decision to proceed with surgery is dependent on several variables. It is dependent on the extent and complexity of the injury. It is dependent on the patient including comorbidities or the patient’s goals and desires. For example, the patient may have the expectation of looking exactly the same as they did before the injury, and sometimes this goal is not realistic. It is also dependent on the
surgeon’s judgement and comfort level with performing the surgery. **There are some “hard” indications for surgery including:**

1. **Significant enophthalmos (>2mm)**
2. **EOM entrapment: Especially if this causes an oculocardiac reflex with hemodynamic instability**
3. **Persistent diplopia**
4. **Large orbital wall defect (>2.5cm^2 area)**
5. **Large orbital floor defect (>50%): This will usually lead to enophthalmos**

Some displaced maxillary fractures may require disimpaction even before placing the patient in intermaxillary fixation. This can be done with a Rowe-Killey instrument, which has a curved and a straight blade. The straight blade is placed along the nasal floor and the curved blade is placed along the palate (Slide 40). Intermaxillary fixation is pursued differently for dentulous than for edentulous patients. For dentulous patients, arch bars and intermaxillary fixation can be used to reestablish pretrauma occlusion (as shown below). For edentulous patients, splints or dentures can be used with arch bars that are fixed to the maxilla. These require circummandibular wires or drop wires from the zygoma or pyriform rim for stabilization. OMFS is an invaluable ally and resource for creating specialized splints or dentures for edentulous patients.

![Intermaxillary fixation](image)

**Surgical approaches:**

There are multiple approaches depending on the location of the injury. Notably, most Le Fort fractures are combinations of complex fractures that may require multiple or combined surgical approaches. The approaches are:

1. **Sublabial incision:** Excellent for exposure of the zygomaticomaxillary buttresses and pyriform apertures in isolated Le Fort I fractures. The advantage is that this is an easy approach. A disadvantage is that it risks damaging the infraorbital nerves.
2. **Subciliary incision**: This incision is made just below the eyelashes. It is used for Le Fort II fractures involving the infraorbital rim. The advantages are excellent exposure of the infraorbital rim and a well-camouflaged scar. Some disadvantages are that there is a high incidence of scleral show and ectropion (shown below in picture to far right).

3. **Transconjunctival-lateral canthotomy incision**: Another option for Le Fort II fracture involving the infraorbital rim. A lateral canthotomy and cantholysis are performed first, and are then followed by a transconjunctival incision. The advantages of this approach are that it allows excellent exposure of the infraorbital rim and there is no visible scar. The disadvantages are a high risk of ectropion and limited exposure beyond the lateral infraorbital rim.

4. **External Lynch incision**: This was historically used for external ethmoidectomies. It involves a lateral nasal incision that allows for exposure of the nasoethmoid complex in extensive Le Fort II fractures. A major advantage is that this allows excellent exposure to the anterior and posterior ethmoid arteries, which is important in cases of refractory epistaxis. The major disadvantage is that this approach is seldom used today and not familiar to a lot of surgeons.
5. **Extended coronal incision:** This allows exposure of the nasoethmoid complex in extensive Le Fort II fractures. The incision line is variable depending on the patient’s hair pattern. The advantage of this approach is that it avoids visible facial scars and also provides excellent exposure to the medial orbit and frontal sinus. The disadvantage is that it is limited to the upper facial skeleton.

6. **Supratarsal (AKA upper blepharoplasty incision):** This involves an incision in the lateral half of the upper lid. It is a good option for Le Fort III fractures involving the zygomatic process of the maxilla. It also provides great exposure to the frontozygomatic suture line. The major advantage is that the scar is well concealed. The major disadvantage is that it allows limited exposure beyond the superolateral orbit.

**GOALS OF SURGERY**

1. Reestablish the buttresses.
2. Restore functional elements: Correct orbital volume, orbital contents free of entrapment, patent nasal airway and maxillary ostia, and reestablish pretrauma occlusion.

3. Restore aesthetic landmarks: Orbital rims, nasal dorsum, and malar eminences. It may be impossible to approximate every small maxillary fragment.

**Plates**

1. **Titanium plates**: Titanium plates and screws are considered the gold standard to immobilize displaced fracture segments. Titanium plates are small, inexpensive, and suitable for rigid fixation. One major disadvantage is that some patient’s may need a 2nd operation to remove the hardware if it is causing pain or irritation (i.e. along infraorbital rim). Another disadvantage is that in children these plates may inhibit bone growth. In addition, bone may grow around the plate leading to a bony deformity.

2. **Absorbable plates**: These are an alternative to titanium plates. They retain strength until they are absorbed and thus preclude the need for a 2nd operation to remove them. Due to their absorbable nature, in children they do not impede bony facial growth at the suture lines. In adults they can be less painful than titanium plates and also eliminate any palpable plates along the lateral and infraorbital rim. The major disadvantage of absorbable plates is that their durability remains questionable. A recent article by Baek et. al in the *Archives of Plastic Surgery* looked at the therapeutic efficacy and safety of titanium versus absorbable plates. They analyzed 78 patients with orbital blow-out fractures, 36 of which were treated with absorbable mesh plates and 42 with titanium plates. The followed these patients for complications including enophthalmos, EOM impairment, and diplopia. They found that both groups had good results and that both types of plates were equally effective and safe for orbital wall reconstruction.

**POST-OPERATIVE CARE:**

Post op care should include adequate pain control. Steroids are a reasonable option depending on the extent of the patient’s pain and swelling. They should be started on a liquid or soft diet to avoid exacerbating any fractures, particularly if the patient is in intermaxillary fixation. As discussed previously, prophylactic antibiotics in the postoperative setting have not been shown to be beneficial. In the intraoperative period, if rigid fixation is stable, intermaxillary fixation can be removed at the end of the operation or within one to two weeks. If the stability remains in question, it is advisable to leave the patient in fixation for six to eight weeks in order to maintain occlusion while the bone healing occurs.

**BIBLIOGRAPHY**


National Geographic, the magazine. (October 2014). Silk screws.

Peltier, J. UTMB Department of Otolaryngology Grand Rounds Archives,
