AAST Acute Care Surgery Didactic Curriculum

Facial Trauma

Mbaga Walusimbi, MD

INTRODUCTION

The face plays a pivotal role in daily life including speech, vision, expression of emotions and personal feelings and of course identity and personality. Therefore, recognition of injuries and restoration to normalcy is of utmost importance in the patient's quality of life. The head and neck, especially the maxillofacial region, is vulnerable to trauma because of its position in the human body. Motor vehicle crashes MVC) account for the most, about 70 % [1]. Sports injuries have been reported to be as high as 21.9%. Severity has been reduced dramatically since the introduction of seatbelts [2]. Maxillofacial trauma includes injury to the facial soft tissues, skeletal framework, and visceral organs.
Injuries may be subtle leading to delayed diagnosis despite improved imaging. Significant morbidity including diplopia, deafness, facial paralysis, meningitis, blindness or death can result. The importance of a thorough physical examination cannot be overemphasized, unfortunately, many of the patients have an altered mental status and the physical examination is unreliable or very limited.

The combat zone differs significantly from civilian experience. Improvements in body armor and the use of improvised explosive devices have resulted in an increased incidence of complex craniofacial trauma. An analysis of the experience in Afghanistan and Iraq conflicts during a 1-year period, January 1, 2017, through December 31, 2017, the most common injuries were soft tissue (57%), followed by cranial injuries (44%) and orbital/facial (31%)[3]. Associated truncal and/or extremity injuries were seen in 46 patients (48%). There were marked differences in incidence and pattern of injuries between mechanisms (all $p < 0.05$). While improvised explosive devices had the highest rate of cranial and truncal injuries, gunshot wounds and blunt mechanisms had higher incidences of orbital/facial and neck injuries. Overall, 45% required operative interventions including complex facial reconstruction, craniotomy, and open globe repair. Mortality was 6% with 83% due to associated severe brain injury.

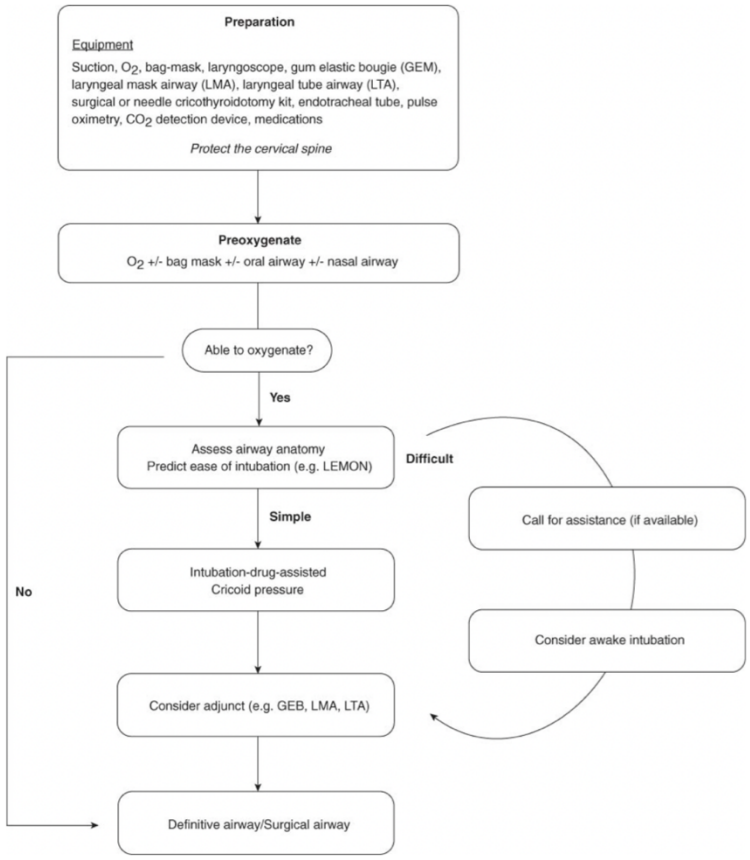
INITIAL ASSESSMENT

A careful history of mechanism of injury and physical examination should be done systematically following ATLS guidelines.

Primary Survey

Airway

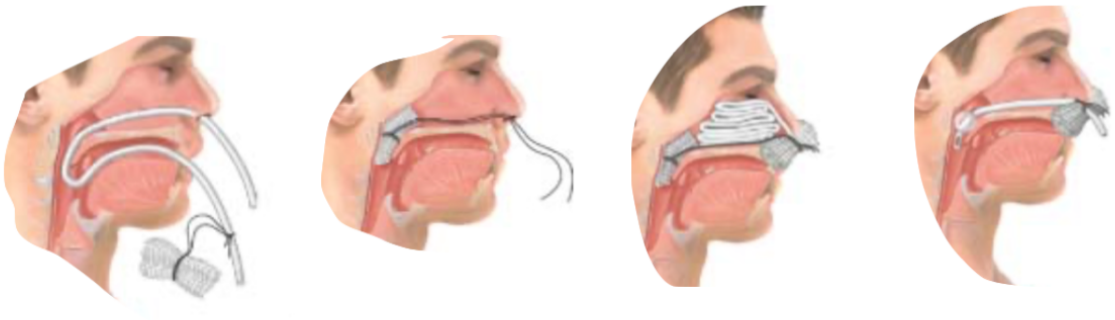
During the initial assessment, life-threatening injuries should be quickly identified. A clear voice and unlabored breathing in general reassuring of airway patency, continuous pulse oximetry is sufficient for monitoring oxygenation. The need for emergency airway control may be for multiple reasons, maxillofacial injuries, even minor ones, have the potential for airway compromise. Decreased level of consciousness and intoxication increase the risk of aspiration of blood, secretions and foreign objects; direct inspection is essential to clear the oral cavity. The source of bleeding can be the mouth from broken teeth, the nose and fractures leading to pooling of blood in the oral cavity. Reverse Trendelenburg position could be used to minimize the risk of aspiration. An expanding neck hematoma, direct facial trauma and swelling which can lead to airway obstruction may call for emergent airway control. Every head and neck trauma should be considered a difficult airway in the face of an uncleared cervical spine in blunt trauma.
An organized algorithm to optimize patient care is useful.



Airway decision scheme Algorithm
From: Britt, L.D., Andrew Peitzman, Philip Barie, Gregory Jurkovich. Acute Care Surgery, 2nd Edition. Wolters Kluwer Health, 2018-09-06. VitalBook file.

Substantial bleeding from a nasal source risking airway compromise, may controlled with nasal packing or balloon compression.

Nasal packing: to control posterior nose bleeding



A: Catheter inserted and packing attached.
B: Packing drawn into position as catheter is removed.
C: Strip tied over bolster to hold packing in place with anterior pack installed
D: Alternative method, using balloon catheter instead of gauze packing.

From: Britt, L.D., Andrew Peitzman, Philip Barie, Gregory Jurkovich. Acute Care Surgery, 2nd Edition. Wolters Kluwer Health, 2018-09-06. VitalBook file

Breathing

Pneumothorax, hemothorax, pulmonary contusion and rib fractures can result in oxygenation-ventilation deficiencies. Increased respiratory effort, a deformed chest wall, chest wall crepitus, decreased breath sounds or desaturation may be the clue before imaging is obtained. Immediate threats to life, such as tension pneumothorax and hemothorax, and cardiac tamponade need to be presumptively treated without a CXR as delays can result in significant morbidity. Immediate needle decompression followed by a chest tube must be performed.

Circulation

Circulation is the next priority in the algorithm, hemorrhage is the second leading cause of death in early trauma [4]. Intravenous (IV) access for fluid resuscitation should be obtained with two peripheral 16-gauge or larger catheters in adults. An intraosseous (IO) access in the proximal humerus or tibia is an alternative in case of difficulty obtaining IV catheter placement. The face has extensive vascularity, facial trauma, especially mid face fractures, are prone to massive blood loss. Persistent nasal or oral bleeding can lead to hemorrhagic shock, death from such injuries has been reported [5].

Secondary survey

When immediate threats to life have been addressed and/or excluded, a detailed organized systematic head to toe physical examination should be done. Maxillofacial injuries rarely occur in isolation, Hogg et al found 87% of patients with maxillofacial trauma had associated injuries which included; skull fractures, traumatic brain injury, cerebral vascular injuries, and cervical spine injuries[1]. Cervical spine injuries range from 1.3%, rose to 5.5% when isolated to only MVC and involved two main levels: C2 (31%) and the two lower cervical vertebrae C6 and C7 (50%)[6].

Structural asymmetry or gross motor deficits, lacerations, abrasions, contusions, and tissue avulsions should be noted, could be clues to a deeper injury. Palpation for localized

tenderness, numbness, asymmetry, deformity, ecchymosis, periorbital edema, otorrhea, and rhinorrhea. The oral cavity is examined including the teeth and alveolar ridges. Midface stability should be appraised.

Anatomy of the maxillofacial region

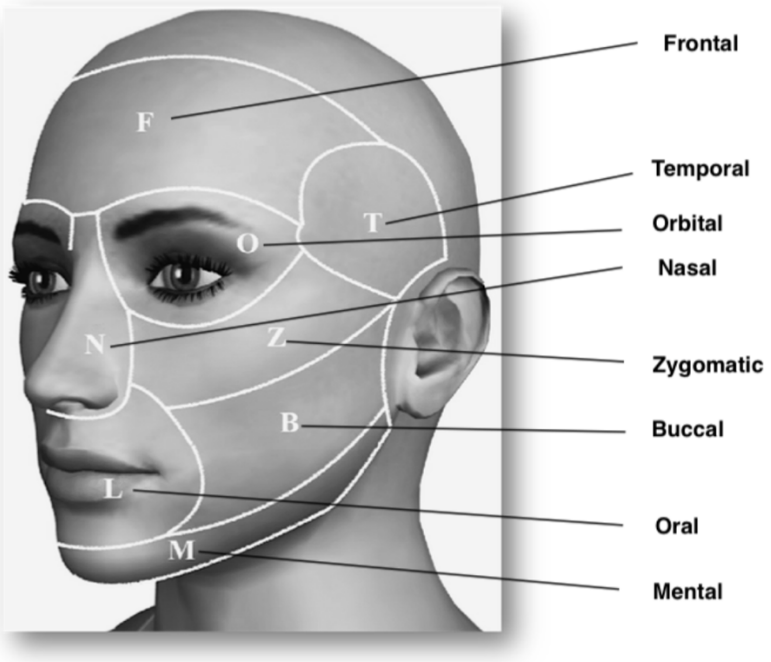
The face extends from the superior margin of the forehead to the chin, and from ear to ear and is divided into parts:

a. superior: frontal, orbital and temporal
b. middle: nasal, infraorbital, zygomatic and auricular
c. inferior: oral, mental, buccal and parotid masseteric region

It is made of soft tissues, skeletal framework, and visceral organs. There are fourteen bones, about twenty skeletal muscles, nerves, and ducts. The muscles are organized into functional groups: buccolabial (oral) group, nasal group, orbital group, epicranial group, and auricular group. All facial muscles originate from the bony and fibrous structures of the skull and insert onto the skin. The facial skeleton can be grouped as fractures of the:

1. The cranial vault includes the frontal sinus.
2. Midface fractures include orbital, nasal bone, naso-orbito-ethmoid, zygomaticomaxillary complex (ZMC), and Le Fort fractures.
3. Mandible

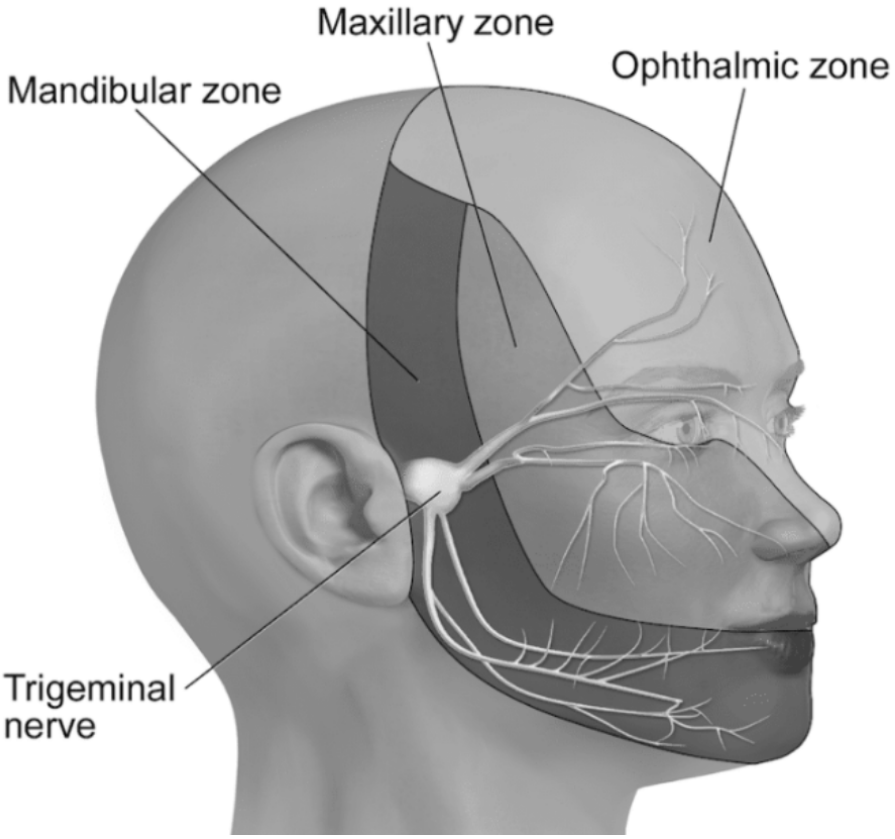
Regions of the face



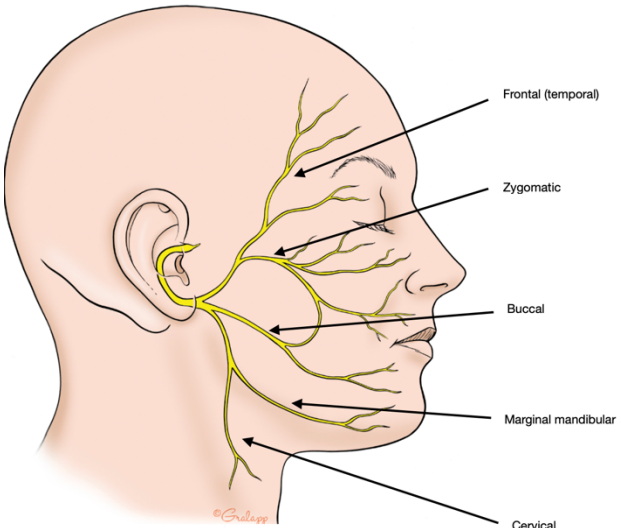
Innervation

The trigeminal nerve (CN V) provides sensory perception to the entire face through three divisions: The ophthalmic nerve (CN V1), the maxillary nerve (CN V2) and the mandibular nerve (CN V3).

Trigeminal nerve distribution



The facial nerve (CN VII) is a mixed nerve, provides motor innervation of the of muscles of facial expression, parasympathetic innervation of the glands of the oral cavity and the lacrimal gland, and sensory innervation of the anterior two-thirds of the tongue.



The facial nerve has five motor segments: forehead, periocular, midface, perioral, and cervical.

Blood supply
Vascular supply is mainly from the facial and the superficial temporal arteries, midface region from the sphenoid palatine and greater palatine arteries off the external carotids. The anterior and posterior ethmoid branches of the ophthalmic artery off the internal carotid artery. A rich subdermal plexus formed from these arteries supplies different parts of the face. The venous blood of the face drains from the subdermal plexus to the deep venous plexus via communicating veins.

Facial skeleton
The facial skeleton can be grouped as fractures of the:

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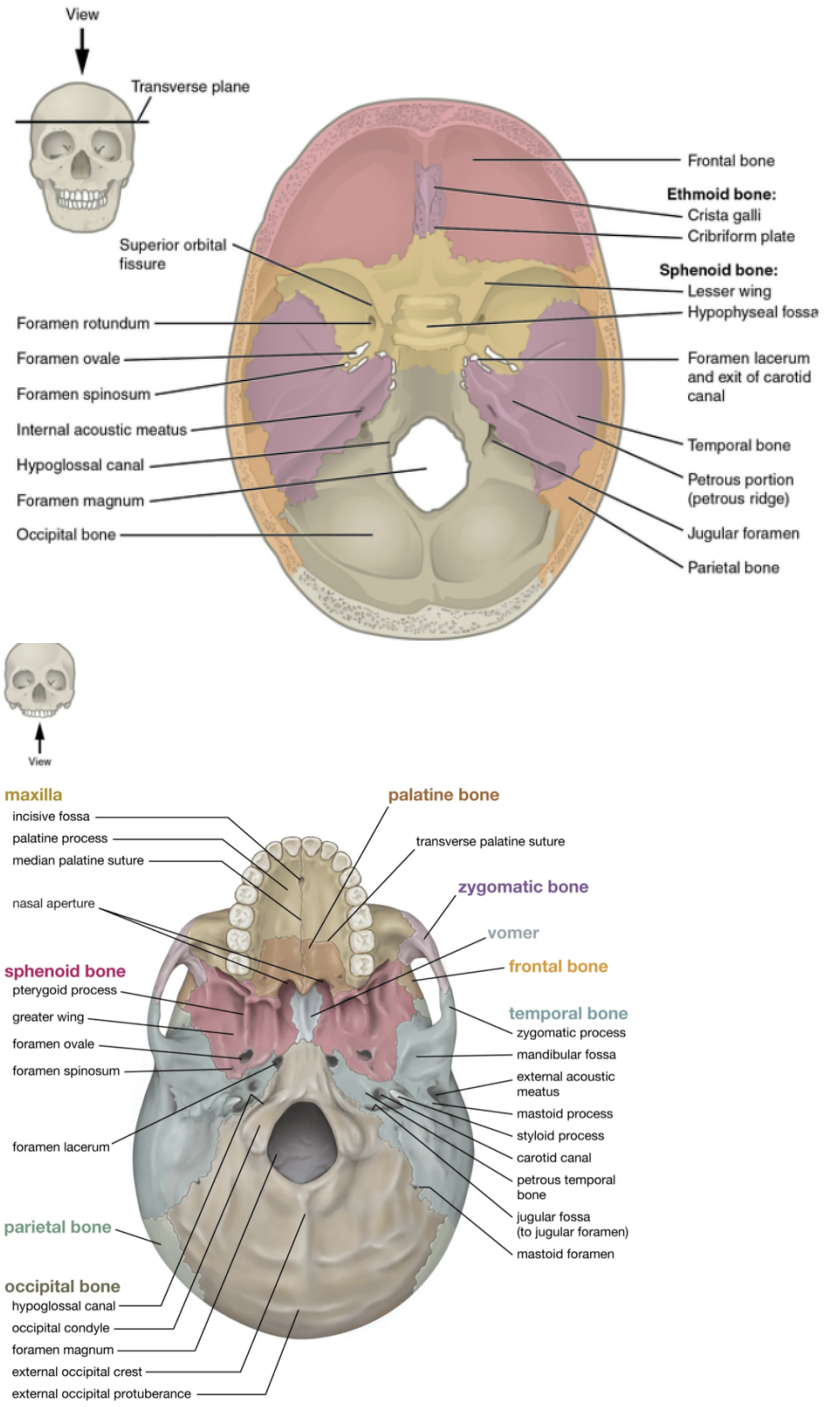
2. Midface fractures include orbital, nasal bone, naso-orbito-ethmoid, zygomaticomaxillary complex (ZMC), and Le Fort fractures.
3. Mandible

SKULL BASE
Five bones make up the skull base, the orbital plate of the frontal bone, cribriform plate of the ethmoid bone, sphenoid bone, occipital bone, and the squamous and petrous portions of the temporal bone. There are numerous cranial foramina that transmit cranial nerves, blood vessels and other structures.



SPECIFIC INJURIES

Face and scalp

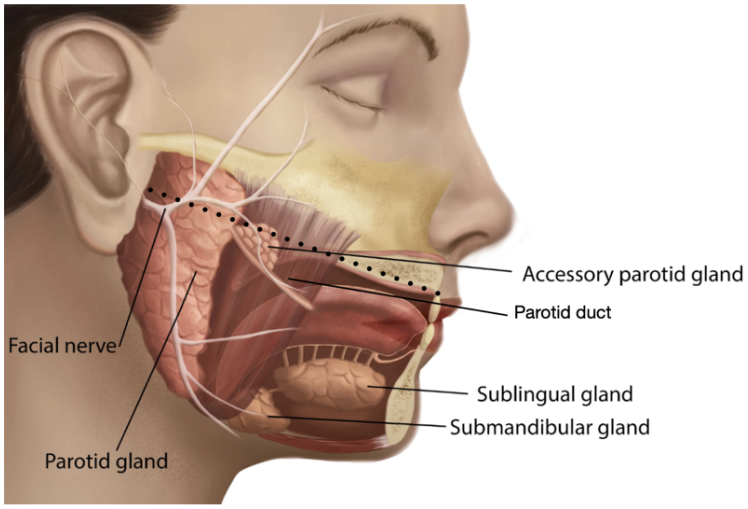
The scalp is a multilayered soft tissue structure covering the covers the calvarium, bordered anteriorly by the face, and laterally and posteriorly by the neck. The arterial supply to the scalp comes from five branches; the supraorbital and supratrochlear arteries off the internal carotid and the occipital artery, superficial temporal artery, and the posterior auricular artery off the external carotid artery. Scalp laceration can bleed

profusely, manual pressure or pressure dressings is the first line in control, vascular clips, scalp hemostatic clips such as Raney clips, suture ligature, or cautery are temporary options in the emergency room. Ultimately scalp wounds should be thoroughly irrigated and examined for size, depth, and tissue loss. Visual inspection for facial asymmetry, in the awake and cooperative patient, ask them to close the eyes tightly, smile, show their teeth, or pull back the corners of the mouth to test facial muscle function.

Cheek

Injury to either Stenson's duct, parotid gland, the facial nerve or its branches can occur and should be ruled out with any laceration, wound or bruise along a line drawn from the tragus of the ear to the midportion of the upper lip. Salivary gland trauma is uncommon, but because of their location, the parotid gland and duct are more susceptible to injury compared to the submandibular and sublingual glands. Temporal bone fractures should also raise suspicion for injury as well.

Anatomy of the parotid glad, parotid duct and facial nerve



..... the path of the parotid duct crosses an imaginary line joining the tragus-antitragus to the middle of the upper lip

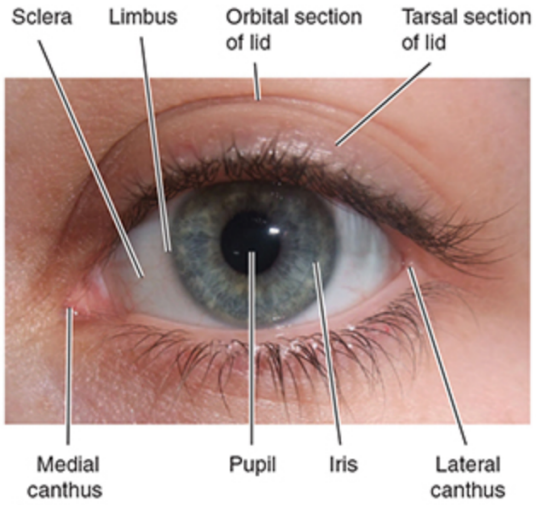
Injury to the gland alone generally involves direct suturing of the enveloping fascia followed by application of a pressure dressing. When the duct is injured, a stent should be placed, and anastomosis is performed with 7–0 or 8–0 nylon. The stent should be left in place for 4 to 6 weeks. A large defect in the duct greater than 1 cm, reconstruction with an autologous facial vein graft may be considered [78].

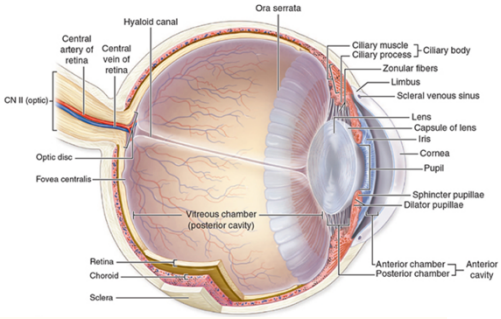
Facial nerve

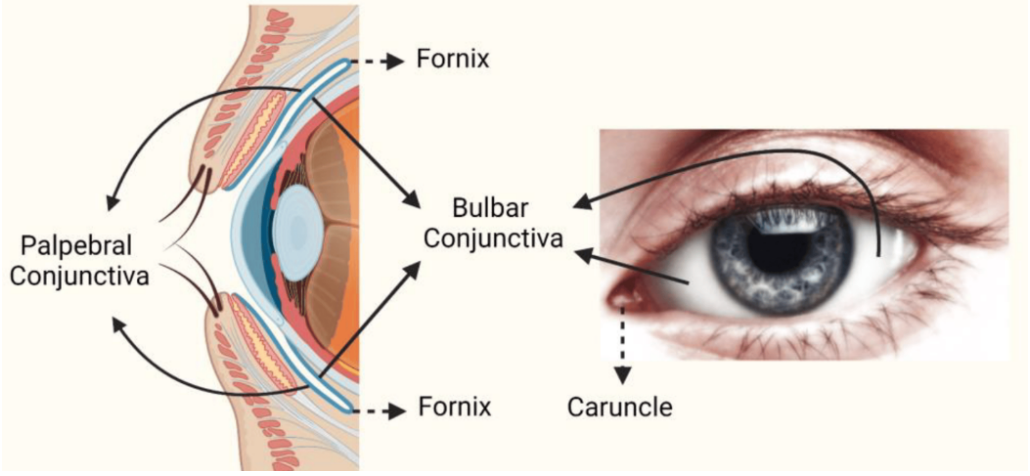
Facial nerve injury occurs in 5% of facial trauma, in blunt trauma most often from temporal bone fractures, and less commonly from mandibular fractures resulting in compression of the nerve or complete transection (brown). Injury at this level results in facial muscle paralysis. Test eyebrow elevation, furrowing, forceful eye closure; lower eyelid position and tension, smiling or lip elevation, lip puckering, flexing of the platysma for an intact facial nerve. Maxillofacial surgery consultation should be done promptly, early exploration and repair in less than 72 hours from injury, has better outcomes.

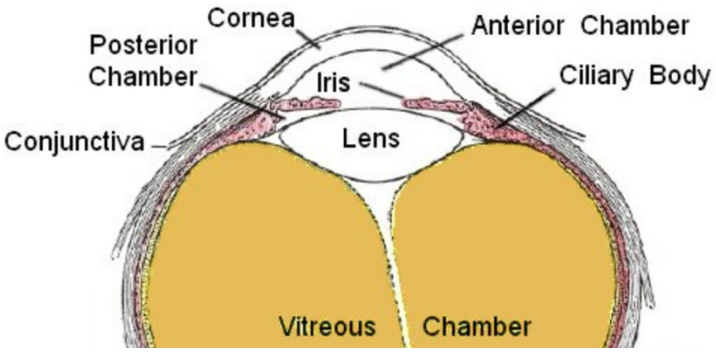
Eyes

The eye sits inside the bony orbit with six attached extraocular muscles which are attached directly to the sclera. The conjunctiva is a thin clear membrane that covers the sclera and inner lining of the eyelids and ends at the cornea. The cornea is a clear, most anterior, layer of the eye, immediately anterior to the anterior chamber, iris, and pupil. The cornea borders the sclera at the corneal limbus and is involved in light refraction. The anterior chamber exists between the cornea and iris and is filled with aqueous fluid. The posterior chamber is between the iris and lens. The vitreous cavity separates the anterior segment from the retina. Light-sensitive photoreceptors are in the retina whose function is to transmit signal to the optic nerve.







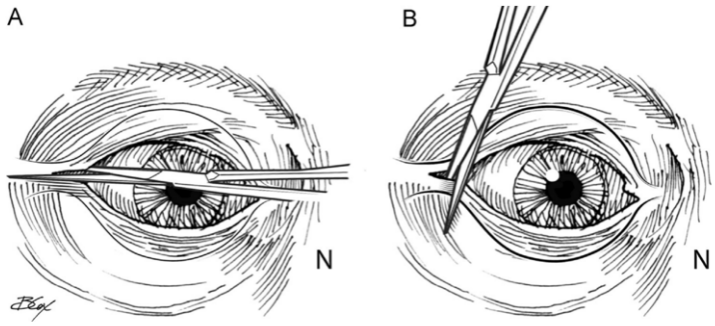


Close inspection must be performed when any signs of injury are present. These include, periocular ecchymosis, eyelid and eyebrow lacerations, conjunctiva laceration or abrasion, sclera lacerations, pupils, orbital step-off. The eye examination must include both visual acuity and extraocular muscle function testing to rule out entrapment from fractures. Intraocular injuries must be identified urgently and referred to ophthalmology.

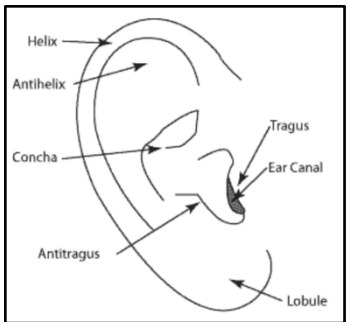
Orbital compartment syndrome

Orbital compartment syndrome is a clinical diagnosis characterized by orbital pain that is out of proportion to the injury, proptosis, periorbital ecchymosis, conjunctival hemorrhage, paralysis of the extraocular muscles, and a tense rock-hard globe to palpation. It is a vision threatening emergency due to a rapid increase in intra-orbital pressure. In the context of facial trauma retrobulbar hematoma is the most likely cause and should be suspected and ruled out during the secondary survey. Patients undergoing massive resuscitation, such as in burns, can also develop elevated intraocular pressures requiring lateral canthotomy. The diagnosis is made by physical examination, severe eye pain, decreased vision, proptosis, a unilateral rock-hard eye globe and elevated intraocular pressure. The exact intraocular pressure (IOP) at which to intervene is debated, IOP greater 30 mm Hg versus 40 mm Hg. The presence of a retrobulbar hematoma on CT scan may be a helpful hint in early recognition and performing the confirmatory testing. This complication is less likely to be missed in the awake non-obtunded patient, because of the disproportionate pain and the decrease in vision. Emergent lateral canthotomy and cantholysis to relieve the pressure are the mainstay of treatment. Lateral canthotomy and cantholysis can be performed rapidly at the bedside. The region between the lateral canthus and lateral orbital rim is anesthetized with 1% lidocaine with 1:100,000 epinephrine. The lower eyelid is retracted outward with toothed forceps, sharp dissecting scissors are used to perform a horizontal incision on the lateral canthus to the lateral bony orbital rim. Next, cantholysis is performed using sharp dissection with the scissors oriented downward, perpendicular to the direction canthal tendon fibers, and the inferior crus of the lateral canthal tendon is transected.

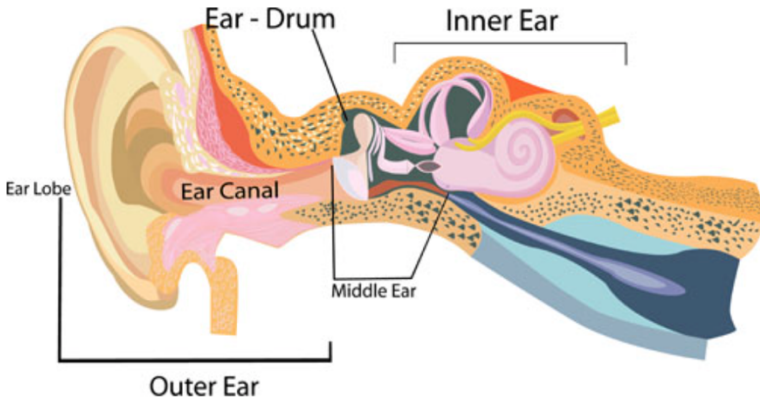
Lateral canthotomy and cantholysis



Ears



The ear is made up of 3 parts: the external ear, middle ear, and inner ear. The external ear includes the auricle and the external auditory meatus, which leads into the external auditory canal and ending at the tympanic membrane (ear drum) . The middle ear starts at the tympanic membrane, 3 bony ossicles, the malleus, incus, and stapes, are found. The middle ear connects to the pharynx by way of the eustachian tube. The inner ear contains the cochlea, vestibule, semicircular canals and the vestibular nerve.



The middle ear is protected by the temporal bone, the facial nerve exits via styloidmastoid foramen lateral to the styloid process. Sensation to the skin of the external ear is by the greater auricular and lesser occipital nerves (spinal nerves), the auriculotemporal nerve (from the trigeminal nerve), and branches of the vagus and facial nerves for the deeper aspects of the auricle and external auditory meatus. Branches of the glossopharyngeal nerve (CN IX) may also contribute to innervation of the auricle or skin overlying the mastoid

process. The ear canal is examined to exclude hemotympanum, otorrhea, or tympanic membrane rupture, which may signal an underlying head injury.
Local anesthesia with or without epinephrine should be used for thorough irrigation of the wounds, pro-phylactic antibiotics in grossly contaminated wounds and animal/human bites. Simple lacerations can be primarily repaired. Avoid excision of exposed cartilage or loose skin, could be useful for expert repair. If hematoma is present, place a bolster after drainage to prevent cauliflower ear deformity

Nose

Nosebleeds after trauma require emergency attention because of the risk to the airway and blood loss. Septal hematoma, lacerations, exposed cartilage and CSF leak should be excluded with can be done with a speculum or anterior rhinoscopy. Nasal septal hematomas should be urgently drained to prevent avascular necrosis of the underlying cartilage. CSF drainage can be from fractured mastoid air cells causing a laceration of the external auditory canal.

SKULL BASE FRACTURES

Up to 24% of patients sustaining blunt head trauma have a skull base fracture (SBF) [9]. There is risk to damaging these critical structures in the neighborhood, including cranial nerves, the internal carotid artery, and the cavernous sinus. A cranial nerve exam should be done. The temporal bone is the most common SBF but may also involve the occipital, sphenoid, ethmoid, and orbital plate of the frontal bone.

The Cranial Nerves and Their Primary Functions

Cranial nerve	Name	Sensory and/or motor	Major function	Location of cells whose axons form the nerve
I	Olfactory nerve	Sensory	Sense of smell	Nasal epithelium
II	Optic nerve	Sensory	Vision	Retina
III	Oculomotor nerve	Motor	Eye movements; pupillary constriction and accommodation; muscle of upper eyelid	Oculomotor nucleus in midbrain; Edinger–Westphal nucleus in midbrain
IV	Trochlear nerve	Motor	Eye movements (intorsion, downward gaze)	Trochlear nucleus in midbrain
V	Trigeminal nerve	Sensory and motor	Somatic sensation from face, mouth, cornea; muscles of mastication	Trigeminal motor nucleus in pons; trigeminal sensory ganglion (the gasserian ganglion)
VI	Abducens nerve	Motor	Eye movements (abduction or lateral movements)	Abducens nucleus in pons
VII	Facial nerve	Sensory and motor	Controls the muscles of facial expression; taste from anterior tongue; lacrimal and salivary glands	Facial motor nucleus in pons; superior salivatory nuclei in pons; geniculate ganglion
VIII	Vestibulocochlear (auditory) nerve	Sensory	Hearing; sense of balance	Spiral ganglion; vestibular (Scarpa's) ganglion
IX	Glossopharyngeal nerve	Sensory and motor	Sensation from posterior tongue and pharynx; taste from posterior tongue; carotid baroreceptors and chemoreceptors; salivary gland	Nucleus ambiguus in medulla; inferior salivatory nucleus in pons; glossopharyngeal ganglia
X	Vagus nerve	Sensory and motor	Autonomic functions of gut; cardiac inhibition; sensation from larynx and pharynx; muscles of vocal cords; swallowing	Dorsal motor nucleus of vagus; nucleus ambiguus; vagal nerve ganglion
XI	Spinal accessory nerve	Motor	Shoulder and neck muscles	Spinal accessory nucleus in superior cervical cord
XII	Hypoglossal nerve	Motor	Movements of tongue	Hypoglossal nucleus in medulla

Temporal bone fractures

The signs of temporal bone fractures include blood in the external auditory canal, hemotympanum, ecchymosis over the mastoid bone (Battles sign), otorrhea, hearing loss, vestibular dysfunction, and facial nerve paresis or paralysis.

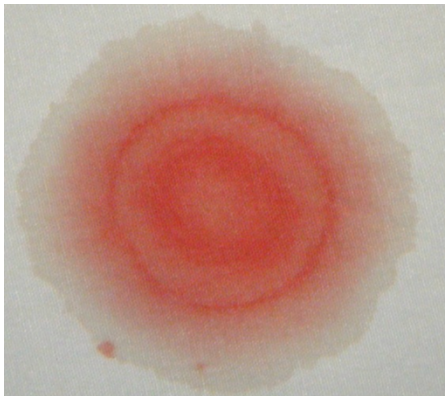
Complications associated with SBF

- CSF leak/fistula
- Meningitis

- Pneumocephalus
- Cavernous sinus thrombosis
- Carotid dissection, pseudoaneurysm or thrombosis
- Carotid-cavernous fistula
- Injury to cranial nerves III, IV, VI, VII and VIII

CSF Fistula: Rhinorrhea and Otorrhea

SBF may lacerate the arachnoid and dura creating a CSF fistula, an abnormal communication between the subarachnoid space and the pneumatized part of the skull base resulting in rhinorrhea or otorrhea. Historically, 10 to 30% of SBF will develop a CSF fistula, with 80% occurring within 48 hours of injury [9]. More recent studies have reported lower ranges, Click here to enter text.MacCutheon et al found the incidence of 1.75% in 10,761 adults patients with SBF, (2.33% in pediatrics),[10]; 4% in (199 of 4,944 patients with skull base fractures were reported by Stoppa et al [11]. Although the actual incidence may be lower, the risks remain. Meningitis and pneumocephalus are the most common complications of CSF leaks. Stoppa et al, reported an incidence of 28% of CSF leaks resulting in meningitis in their study, and a one-year mortality of 16%. This was the same as the historical rates in the literature. To make the diagnosis of SBF, CT is a useful tool but misses some fractures, yielding a negative predictive value of 0.5 [12]. CSF leakage is indirect evidence of presence of a SBF skull base. Therefore, when there is otorrhea or rhinorrhea CSF leakage must be excluded. Confirmatory testing is evolving, shifting away from glucose strip testing, and instead using the β-2- transferrin assay. β-2- transferrin test has a sensitivity of 99% and specificity of 97% [13] A rapid bedside “halo or double-ring” test, although nonspecific, can be performed when there is clinical suspicion. It is based on the principle of chromatography; a few drops of suspicious fluid are placed on tissue paper. Because CSF has a more rapid diffusion pattern than blood, a larger, clearer CSF ring will surround the sanguineous central ring.



Once a CSF leak is confirmed and surgical fixation is the choice, accurate localization with imaging should be done. Radionuclide and CT cisternography with contrast have been the historical standards but have low sensitivities. High -resolution CT/MRI combination methods may show promise in localizing CSF leaks.

Management Skull base fractures

In the absence of a CSF fistula, temporal bone fracture, facial paralysis, hearing loss, or blindness, the initial management is still conservative, total bed rest with the head of bed elevated. The use of antibiotic prophylaxis in patients with SBF remains controversial, a Cochrane review from 2015 found insufficient evidence to support the use of prophylactic antibiotics in SBF patients, whether CSF leak was present or not [14]. If conservative management fails after 5-7 days, imaging to localize the fracture may be done for operative.

CRANIOFACIAL FRACTURES

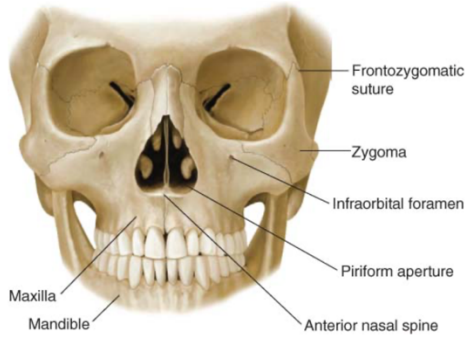
Sinus fractures

The frontal sinus comprises the thick anterior bone, and a thinner posterior table and constitutes part of the anterior cranial fossa. Because frontal sinus fractures require high-energy mechanism, up to 75% have serious associated injuries (Trauma). Therefore, when there is soft tissue injury in the forehead, fractures should be ruled out, there may be an obvious bony depression or step-off. Expert consultation is necessary when these injuries are diagnosed for further management.

Orbital fractures

Fractures tend to occur in the orbital floor because it is the thinnest and weakest area. Soft tissue can herniate into the maxillary sinuses and get entrapped. Entrapment of the inferior oblique or inferior rectus muscle can lead to diplopia and restriction of globe movement. The globe is displaced posteriorly and inferiorly, which causes enophthalmos and further diplopia.

Maxillary fractures



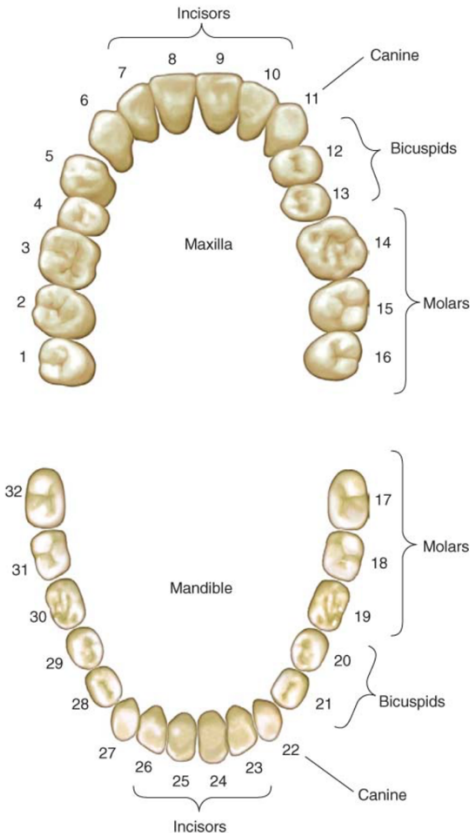
Maxillary fractures tend to be from significant blunt facial trauma and follow a typical fracture pattern classified. There are three fracture patterns classified by the Le Fort system:

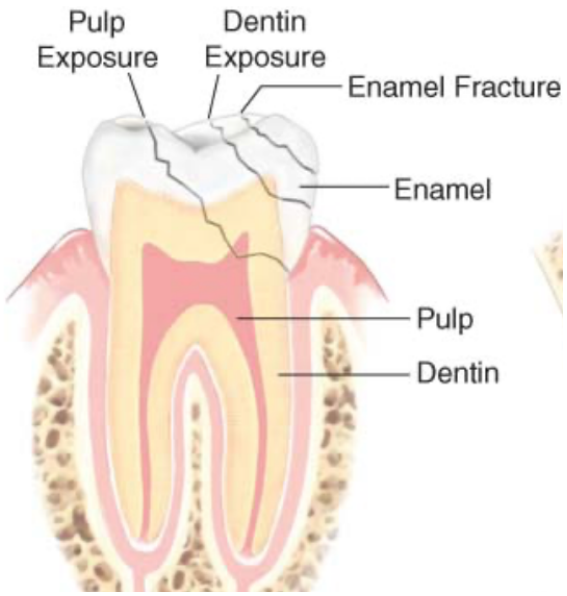
LeFort I — a crack separates the upper jawbone and teeth from the other facial bones.
LeFort II — includes the upper jaw as well as the nasal bones.
LeFort III — includes the eye sockets and the bridge of the nose and is known as craniofacial separation.

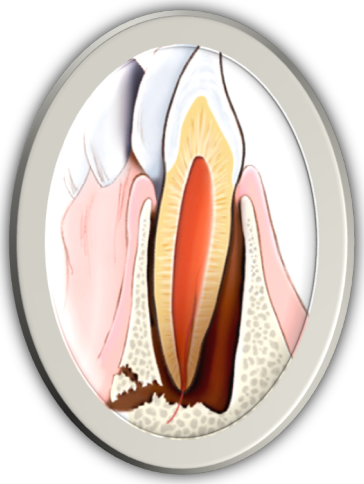
Dentoalveolar Injuries

In general, up to 32 permanent teeth are present in adults, and 20 primary teeth in children. Between the ages 6 to 12 years is the mixed dentition stage, permanent dentition is still unerupted in the alveolus. A thorough review of head, neck, chest, and abdomen with imaging is necessary to account for any missing teeth rule out aspiration or swallowing of the tooth [15]. Partially or fully avulsed teeth should be removed and placed in a proper storage solution, milk serves that purpose well or Hank's balanced salt solution found in Save-A-Tooth kits (3M Health Care, St. Paul, MN) (Acute Care surgery) successful reimplantation is time sensitive as the periodontal tissues attached to the teeth can desiccate, prompt expert consult should be done promptly. There is limited research on the timing of re-implantation, 1 to 3 hours seems to offer the best outcome.
When performing reimplantation, care should be taken to avoid socket disturbance. When a tooth is fully avulsed, gently rinse the tooth with water (without manipulating the tooth root) and carefully place it back into the socket to allow it to "key" into place. A partially avulsed tooth (or those that are extruded or laterally displaced) should not be removed. Instead, reduction should be performed with careful attention to avoid unnecessary trauma. Reimplantation may be painful, therefore, lidocaine without epinephrine is recommended to infiltrate the buccal sulcus and gum regions on the outer side of the alveolar ridge adjacent to the socket requiring intervention. The reimplanted tooth requires stabilization for optimal outcomes with a splint, wire, or arch bar for several weeks (ACS 2nd ed).
The Universal Tooth Designation System is used commonly as a standard in tooth designation

Ellis dental fracture system







Class I fractures: only the enamel, no pain, delayed or outpatient care.
Class II and III fractures: the innervated dentin and dental pulp are exposed, can be very painful, require more immediate attention and restoration.

Orbital Fractures
Seen mostly from midfacial trauma from assault, MVC and falls in adults, for children mostly sports related. Five skull bones form the orbit: frontal bone (superior orbital rim, orbital roof), sphenoid and zygoma bones (lateral orbit), zygoma and maxillary bones (infraorbital rim and orbital floor), and the maxillary and ethmoid bones (medial orbit). Fractures of the orbit may involve one or more orbital walls and/or the orbital rim. Presence of periorbital ecchymosis, diplopia, numbness in the infraorbital nerve distribution, (lower eyelid, ipsilateral side of the nose, and the upper lip), and orbital emphysema should suspect an orbital fracture. Other signs include, proptosis (orbital hematoma), extrusion of intraocular contents, severe conjunctival hemorrhage and a tear-shaped pupil (globe rupture), orbital dystonia or enophthalmos (orbital floor fracture), and a widened intercanthal distance (medial canthal ligament disruption) pertain to presence of an orbital fracture.