EMERGENCY MEDICINE PRACTICE

EBMEDICINE.NET

AN EVIDENCE-BASED APPROACH TO EMERGENCY MEDICINE

Maxillofacial Trauma: Challenges In ED Diagnosis And Management

February 2008
Volume 10, Number 2

Authors

Charles Stewart, MD, FACEP, FAAEM
Director of Research, Department of Emergency Medicine, University of Oklahoma, Oklahoma Institute of Disaster and Emergency Medicine, Tulsa, OK

Peer Reviewers

James F. Fiechtl, MD
Assistant Professor, Department of Emergency Medicine, Vanderbilt University Medical Center

Stephen J. Wolf, MD
Director, Residency in Emergency Medicine, Denver Health Medical Center, Denver, Colorado

CME Objectives

Upon completion of this article, you should be able to:

1. List the steps in assessing a maxillofacial injury.
2. Describe immediate emergency interventions for specific maxillofacial injuries.
3. Evaluate the severity of an emergency involving maxillofacial trauma.
4. Identify appropriate imaging for dental, oral, and maxillofacial trauma.

Date of original release: February 1, 2008

Date of most recent review: January 10, 2008

Termination date: February 1, 2011

Time to complete activity: 4 hours

Medium: Print & online

Method of participation: Print or online answer form and evaluation

Prior to beginning this activity, see "Physician CME Information" on the back page.

2:20 a.m. Saturday morning: You just finished with a nine-year-old, new-onset diabetic in ketoacidosis and a 37-year-old with an inferior myocardial infarction. There aren't any patients in the waiting room and the house supervisor is visiting. She uses the 'Q' word and asks if all is quiet now … "Bad choice," you think.

Just then, the survival ambulance service calls with an intoxicated patient who has obviously been assaulted. This 19-year-old male was at a bar when he 'laid moves' on a female patron. Her husband objected to the situation and applied 'remedial correction' several times with a beer bottle to the patient's face. He apparently stopped only when the beer bottle broke. The patient is responsive to verbal stimuli, with abundant curses and imprecations. He is in spinal immobilization and strapped to a back board both for his protection and the protection of the EMS crew. The paramedics note that the patient's respiratory rate is 20, his heart rate is 108, and his bedside glucose test measures 92. They have been unable to obtain intravenous access. They note significant facial edema on the left side, a nasal deformity, jaw deformity, and abundant epistaxis.

Among the myriad injuries seen in the emergency department, facial trauma is one of the most common. Trauma to the maxillofacial area mandates special attention. Due to their close proximity and frequent involvement, the vital structures in the head and neck region must be evaluated whenever the head and face are injured. Additionally, the psychological impact of disfigurement associated with facial and maxillary trauma can be devastating.[1-3] Given the broad variety of facial injuries and potential concomitant

Accreditation: This activity has been planned and implemented in accordance with the Essentials and Standards of the Accreditation Council for Continuing Medical Education (ACCME) through the joint sponsorship of Mount Sinai School of Medicine and *Emergency Medicine Practice.* The Mount Sinai School of Medicine is accredited by the ACCME to provide continuing medical education for physicians. **Faculty Disclosure:** Dr. Stewart, Dr. Fiechtl, and Dr. Wolf report no significant financial interest or other relationship with the manufacturer(s) of any commercial product(s) discussed in this educational presentation. **Commercial Support:** *Emergency Medicine Practice* does not accept any commercial support.

complications, management can be challenging even for the most experienced clinicians.

Goals in the treatment of facial injuries include a return of normal ocular, masticatory, and nasal function, restoration of speech, rapid bone healing, and an acceptable facial and dental esthetic result. With ever-increasing sophistication in imaging, emergency providers can rapidly diagnose small facial fractures. However, subtle complex facial fractures with CSF leaks, temporal bone fractures, and cranial nerve injuries can remain undiagnosed. These missed or delayed diagnoses can lead to significant morbidity or death.

The goal of this article is to assist the emergency physician in the initial management of patients who have sustained a facial injury. Since the emergency physician is rarely involved in operative decisions, there is no effort to discuss the surgical treatment of these fractures and soft tissue injuries beyond the initial stabilization. This article does not discuss pure ocular or lid lesions.

Critical Appraisal Of The Literature

An electronic literature search of MEDLINE and PubMed was performed to obtain the references for this publication. The search words maxillofacial, trauma, mandibular, maxillary, facial, and imaging were used. The reference section of each article was reviewed for additional references pertinent to the subject matter. There are few prospective studies of maxillofacial fractures and their complications. There are many anecdotal case reports and retrospective series examinations. As such, the majority of the studies reviewed were retrospective in nature and were observational rather than designed.

There are no national practice guidelines available for patients presenting with maxillofacial trauma, and there are no Cochrane studies that deal directly with maxillofacial trauma. Throughout the literature, the indications for surgery and the timing of surgery vary tremendously. This lack of clear data makes the management of many facial fractures controversial.

Best Evidence Topics (Best Bets, available at www.bestbets.org) were found for the following considerations:

- Radiographs for facial trauma
- The use of antibiotics for orbital floor fractures
- Radiological diagnosis of mandibular fractures
- Early manipulation of nasal fractures
- The utility of the tongue blade test for the diagnosis of mandibular fractures

Epidemiology And Etiology

More than three million facial injuries occur in the United States each year.[4] Sports, accidental falls, motor vehicle accidents, assaults, and work-related accidents account for the majority of maxillofacial injuries.[4,5] Depending on the trauma center, assaults vie with motor vehicle accidents for the number one spot.[6-9] Among sport-related injuries, boxing is particularly associated with a high incidence facial injuries.[10]

In a series of over 200 consecutive facial fractures seen in an urban trauma center, assaults accounted for nearly 50%.[4] The adult male to female ratio is 3:1, but this is reduced to 3:2 in pediatric patients.

The incidence of concomitant major injuries is reported to be as high as 50% in high-impact facial fractures, compared to 21% for lower impact fractures.[6] Fractures are more commonly associated with motor vehicle collisions, rather than other blunt trauma. With respect to this topic, it is worthwhile to point out that airbag deployment considerably decreases the incidence and severity of orbital fractures for front-seat occupants in frontal automobile crashes.[5,11]

Fractures of the facial skeleton are relatively uncommon in children and adolescents.[12,13] This low incidence may reflect the underdeveloped facial skeleton and paranasal sinuses as well as the unerupted dentition which provide additional strength to the mandible and maxilla. The well-known flexibility of the pediatric skeleton will also reduce the frequency of fractures.

Pathophysiology

Nasal Fractures

The nose is the most frequently injured facial structure, accounting for approximately 40% of bony injuries in facial trauma.[14] Assaults and sports injuries cause most nasal fractures in adults, followed by falls and motor vehicle collisions. Play and sports account for most nasal fractures in children. Nasal fractures may occur in association with other facial injuries or by themselves.

The nose is supported by cartilage anteriorly and inferiorly and by bone posteriorly and superiorly. The paired nasal bones, the maxilla, and the nasal process of the frontal bone form a framework that supports the cartilaginous parts of the nose. The paired nasal bones are wedge-shaped and joined at the midline. The lower half of the nasal bone is thin and broad, whereas the upper portion is thicker and is firmly supported by an articulation with the frontal bone and the frontal process of the maxilla. The thinner portion of the nose is more liable to fracture while the thicker portion near the frontal bone is more difficult to injure.[15] Nonetheless, the force required to fracture the nasal bones is less than for any other facial bone.[15] Likewise, due to the natural taper of the nose, the supporting nasal septum becomes increasingly thin and tends to fracture more towards the tip of the nose. A fracture of the septum unfavorably affects the alignment of the nose during the healing process.

Many different methods have been proposed for classifying nasal and septal fractures. Factors to consider in patients with an injury to the nose include:

1. Cause of the trauma
    a. A direct frontal blow can depress the dorsum of the nose, causing the bones to telescope posteriorly.
    b. A strong force from any direction can comminute the nasal bones and cause an "open-book" fracture of the nose.[15]
    c. A lateral blow can cause displacement to the opposite side of the face and leave a depression on the side of the impact.
    d. Traction and torsion injuries can cause disruption of the cartilage.[16]
2. History of prior facial injuries
3. Any prior nasal deformity
4. Any prior nasal obstruction

The patient's conception of the original shape of his/her nose is often inaccurate, and edema may mask bone deviation. Comparison with a picture taken prior to trauma is often helpful. Such pictures are often found in ID documents such as a passport or driver's license.

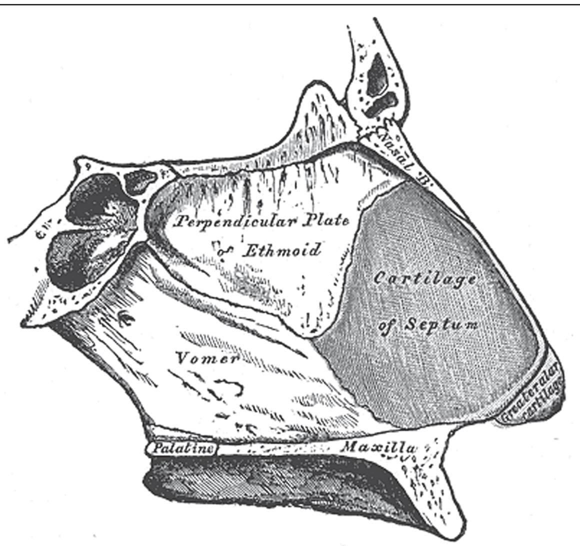
Bony fractures of the nose may involve one or both nasal bones, the frontal process of the maxilla, the bony septum, and — in severe trauma — the nasal-orbital-ethmoid complex (**Figure 1**). The most likely area of fracture of the nasal bones is the thinner lower two-thirds.[16] Simple nasal fractures must be separated from the more serious naso-orbito-ethmoid fracture (NOE fracture) where the fracture extends into the nose through the ethmoid bones. These fractures may cause injury to the dura and a subsequent cerebrospinal fluid leak.

Suspect a naso-orbito-ethmoid fracture when the patient has telecanthus (widening of the nasal bridge with a detached medial canthus). These patients will often have either CSF rhinorrhea, epistaxis, or both.

Epistaxis is commonly associated with nasal trauma and is easily explained by the dense vascular network (Kiesselbach's plexus) that supplies the nose. Bleeding can also originate from other locations within the nose when the nose is fractured. Anterior nasal bleeding can originate from the anterior ethmoid artery (a branch of the ophthalmic artery) and posteriorly from a branch of the sphenopalatine artery. Packing the nose usually controls this hemorrhage. If packing fails to control the bleeding, consultation with an otolaryngologist is appropriate as specific vessel ligation may be needed.[17]

Complications most commonly encountered with nasal fractures include septal hematoma, nasal obstruction, and significant deformity. An unrecognized septal hematoma may strip the underlying septal cartilage of its vascular supply which can result in cartilage destruction. Secondary infection of the hematoma, often by *S. aureus*, can occur. Undiagnosed hematomas of the nasal septum that progress to abscess formation can cause cartilage necrosis and loss of nasal support, leading to the so-called "saddle-nose deformity" and septal perforation.

Figure 1. Bones And Cartilages Of The Nose (Right Side)



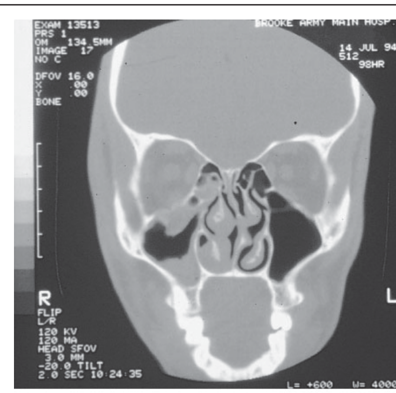
Reprinted from Gray's Anatomy, Henry Gray (1825–1861). Anatomy of the Human Body. 1918.

Orbital Fractures

Trauma to the face can cause a fracture along the weak points of the orbit. The patterns of fractures are well described: orbital-zygomatic (see "Zygomatic Fracture"), naso-orbito-ethmoid (see "Nasal Fracture"), and internal orbital. Different combinations of these basic patterns can produce combined or complex orbital fractures.

The thinnest and weakest area of the orbit is the floor. Typically, the fracture occurs in the posteromedial region of the orbital floor – a "blow-out" fracture (**Figures 2 and 3**). The usual mechanism is a blow to the eye with the forces being transmitted by the soft tissues of the orbit downward through the thin floor of the orbit.[18,19] When this fracture occurs, contents of the orbit (including fat, soft tissues, the inferior oblique muscle, or the inferior rectus muscle) can protrude through the fracture and become entrapped.[20] A retrospective review of 424 patients suggested that patients with a medial orbital floor

Figure 2. CT Of A Blowout Fracture With Entrapment



This demonstrates the entrapped muscle extruding into the maxillary sinus. Reprinted from Stack, Lawrence B. Emergency Medicine Atlas. Copyright © 2007 The McGraw-Hill Companies. All rights reserved.

component of fracture had a significantly higher incidence of diplopia.[21]

Entrapment of the inferior oblique or the inferior rectus muscle can lead to restriction of orbital movements and resultant diplopia. The entrapment of both muscle and soft tissues can displace the globe posteriorly and inferiorly, adding to the diplopia and enophthalmos. The diplopia is most pronounced in upward gaze. Approximately 24% of these fractures are associated with ocular injury as well as the fracture.[22]

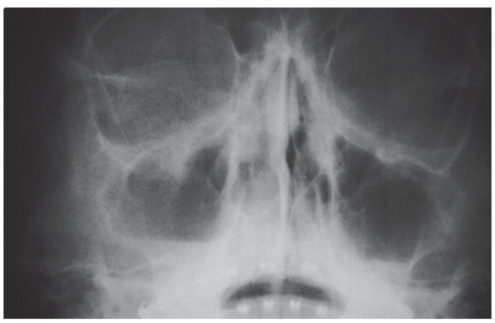
Because the infraorbital nerve passes through the orbital floor, hypesthesia often occurs in its sensory distribution with orbital floor fractures (**Figure 4**).

The term "trapdoor" is used to describe fractures with minimal displacement of the bony fragments. Orbital floor fractures in children may have a higher incidence of trapdoor entrapment of muscle or fat; this entrapped orbital tissue can potentially lead to ischemia and necrosis. The softer, more flexible bones in children cause the orbital floor to bend, crack, and form this trapdoor. The resultant tissue displacement can cause a white-eyed appearance.[23,24] In these patients, a shorter time to surgical intervention can yield significantly better outcomes.[25] In children, nausea and vomiting can be predictive of trapdoor fractures with entrapment.

Fractures of the superior, lateral, and inferior rims of the orbit can occur in isolation or in association with other cranio-facial injuries. Careful palpation may reveal a step off at the site of a fracture. Cheek paresthesias are commonly found with inferior orbital rim fractures that traumatize the infraorbital nerve.

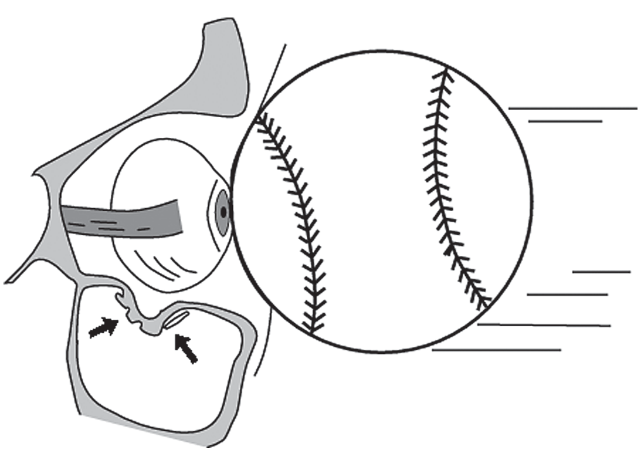
Orbital roof fractures in adults are uncommon and are usually associated with high-impact injuries to the head and face.[26] Multiple facial and neurological complications are common in these injuries. In children, orbital roof fractures are seen with lesser force.

Figure 3. Plain Film Of A Blowout Fracture



This plain film demonstrates a fracture of the floor of the right orbit, with a teardrop sign due to extruded orbital contents. There is an associated air-fluid level in the maxillary sinus due to blood. Note the two lines seen at the inferior orbit: the infraorbital rim and inferior floor of the orbit. These are well visualized on the unaffected side but disrupted on the affected side. Reprinted from Knoop, Kevin J. Emergency Medicine Atlas. Copyright © 2007 The McGraw-Hill Companies. All rights reserved.

Figure 4. Blow-Out Fracture Mechanism



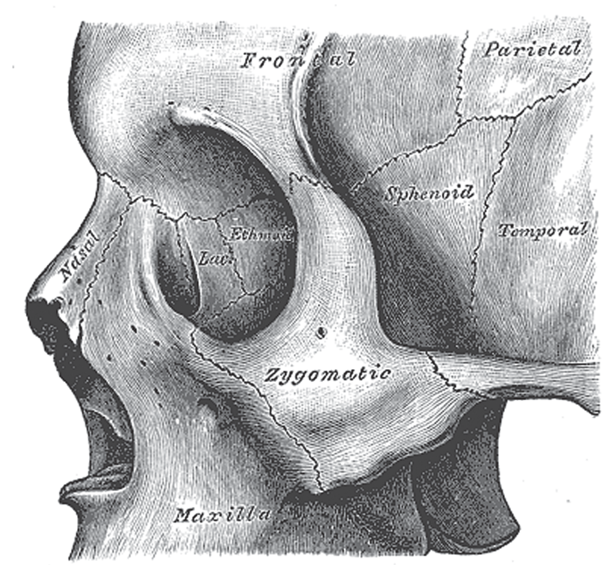
With permission from Richardson, Michael L., University of Washington, Department of Radiology. www.rad.washington.edu/mskbook/facialfx.html

Zygomatic Fractures

The zygoma forms the malar eminence, determines the amount of anterior and lateral cheek projection, and supports the lateral wall and floor of the orbit. It is a prominent bone in the face, making it subject to trauma and fractures. There are four parts or 'processes' that comprise the zygoma: the maxillary process, the temporal process, the frontal process, and the orbital process. Inferiorly, the maxillary process articulates with the maxilla at the zygomaticomaxillary suture. Laterally, the temporal process of the zygoma joins the temporal bone to form the zygomatic arch, anterior to the auditory canal. Medially, the orbital process articulates with the greater wing of the sphenoid bone. Superiorly, the frontal process articulates with the frontal bone at the zygomaticofrontal suture (**Figure 5**).

Because the zygoma is a thick bone, it is rare to have an isolated fracture of the zygoma. Most

Figure 5. Nasal And Zygomatic Anatomy



Reprinted from Gray's Anatomy, Henry Gray (1825–1861). Anatomy of the Human Body. 1918.

commonly, the fracture extends through adjacent bones which are often thinner. Zygomatic arch fractures tend to occur in two (occasionally three) places along the arch of the zygoma (**Figure 6**). A fracture may occur at each end of the arch as well as in the middle, resulting in a v-shaped fracture. This can impinge on the underlying temporalis muscle, resulting in trismus.

A zygomaticomaxillary fracture (tripod or malar fracture) results from a direct blow to the cheek. The fractures occur at the articulation of the zygoma with the frontal bone and the zygomatic arch. These fractures are orbital fractures because the internal orbit can be disrupted by the displacement of the zygomatic body. The maxillary component of this fracture may include the anterolateral wall of the maxillary antrum. Zygomaticomaxillary fractures are often associated with severe facial edema, so the true extent of the injury may be obscured. As with other fractures involving the orbit, diplopia may be reported by the patient. Depression of the inferior orbital rim or parathesia in the distribution of the infraorbital nerve suggests extension into the orbit or maxilla.

Mandibular Fractures

The mandible surrounds the tongue and is the only mobile cranial bone; it contains the lower dentition and significant blood vessels, muscles, and nerves. The mandible is actually two bones fused in the midline symphysis. Each bone has a thick buccal and lingual cortex and a thin medullary cavity. The inferior alveolar nerve enters the mandible at the mandibular foramen with the inferior alveolar artery and crosses the medullary cavity, exiting at the mental foramen. It traverses the medullary cavity below the level of the tooth roots. This nerve provides sensation to the mandibular teeth as well as the skin and mucosa of the lower lip.

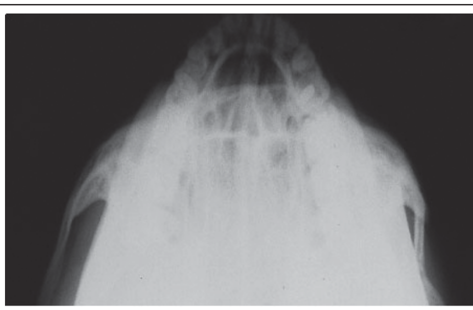
The mandible is connected to the cranium at the temporomandibular joint. The appropriate functioning of the mandible determines the occlusal contact of the teeth. Mandibular fractures can cause a variety of short and long-term impairments including temporomandibular joint pain, malocclusion, inability to masticate, salivary disorders, obstructive sleep apnea, and chronic pain. Mandibular fractures can be debilitating and disfiguring. The mandible is the tenth most commonly injured bone in the body and the second most commonly injured bone in the face.[27] Fractures of the mandible can be found in the symphysis, body, angle, ramus, and condyle or subcondylar areas (**Figure 7**).[28]

When the maxillary area or the mandibular are damaged, the examiner should also suspect a possible injury to the parotid gland and its associated duct. The parotid gland lies under the middle third of a line between the commissure of the lips and the tragus of the ear. Any laceration in this area may damage the parotid duct and exploration of the wound should be performed to evaluate this possibility. If ductal injury has occurred, identification of the proximal and distal segments with primary reanastomosis is the ideal therapy. Reanastomosis is performed over a polyurethane catheter which may be removed when adequate healing has occurred.

The mandible is often fractured at more than one location because of the ring structure formed by its articulation at the temporomandibular joint. In addition to the traditional fracture classifications — open, closed, simple, complex, or comminuted — mandibular fractures are also described as favorable or unfavorable, depending on whether the muscles of mastication tend to reduce or distract the fracture, respectively.

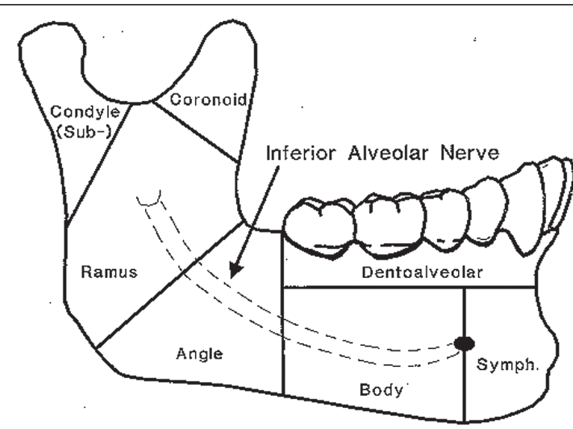
Alveolar fractures occur just above the teeth in the alveolar portion of the maxilla or mandible. Often, a plate or a group of teeth are loose and blood may be found at the gingiva. Dentoalveolar fractures and fractures with dentoalveolar extension involve only the alveolar ridge and associated teeth and are, by definition, open fractures (**Figure 8**).

Figure 6. Zygomatic Arch Fracture



Jug-handle view of the zygomatic arch demonstrating a depressed fracture. In such a case, operative reduction can be delayed for several days. Reprinted from McGuirk, Timothy D. Emergency Medicine Atlas. Copyright © 2007 The McGraw-Hill Companies. All rights reserved.

Figure 7. Mandible Showing Anatomic Regions Where Fractures Occur



This figure was published in Emergency Medicine Clinics of North America, *Volume 18 Number 3, Edward Ellis III and Kirk Scott, "Assessment of patients with facial fractures," Copyright Elsevier 2000. Reprinted with permission.*

The cause of the injury has some relationship to the location of the fracture. A population-based analysis of over ten thousand hospitalizations for mandibular fractures described the incidence and causes of these fractures.[27] In a large data study, the most common anatomic site for a fracture of the mandible was the body of the mandible from the symphysis to the angle of the mandible, including the alveolar ridge (43.5%).[27] Approximately 24.1% occurred in the ascending ramus of the mandible (between the condyle and the angle). The remaining mandibular fractures occurred in multiple regions or the region was not specified. This study did not deal with patients who were not hospitalized, so there may be some differences in the out-patient population.

This study found the most common cause of mandibular fractures to be assaults (50-75%).[27,32] Injuries sustained in altercations are more often located in the mandibular angle region. They are more common on the left than on the right, since the right-handed person will usually strike a blow on the left jaw.[33] In altercations, the combination of a fracture of the mandibular angle on the side of impact and the opposite mandibular symphysis or body fracture is common.[33] The next most common cause was motor vehicle collisions, followed by falls. The rates for assaults were three times higher than for motor vehicle collisions. The study showed that use of motorcycle helmets decreased the incidence of mandibular fractures from motor vehicle collisions by 57% in one year alone.[27] High velocity impact also tends to increase the frequency of comminuted fractures and fractures in multiple regions of the mandible.

Although delay in treatment has been implicated in infectious complications in mandibular fractures, this was not shown to be the case in at least one retrospective study.[32] In this study, intravenous drug use was the single largest comorbidity for infectious complications. Likewise, use of perioperative antibiotics had no benefit in reducing the incidence of infections in patients undergoing surgical repair of mandibular fractures.[34] The complication rate of mandibular fractures is most correlated with the severity of the fracture. Minor correlates were alcohol and tobacco use.[35]

Pediatric patients are more likely than adults to sustain a greenstick or incomplete fracture of the mandible.[12,29] This is due to the relative elasticity of the pediatric bones in comparison to the adult's. Because of the tooth buds and developing crypts, pediatric fractures may be longer and more irregular in character than similar fractures in adults.[30] However, they are less likely to have comminution of the fracture. Pediatric mandibular fractures may occur as a result of abuse.[31]

Figure 8. Open Mandibular Fracture

The open fracture line is evident clinically. There is slight misalignment of the teeth. Reprinted from Amrhein, Edward S.

Maxillary Fractures

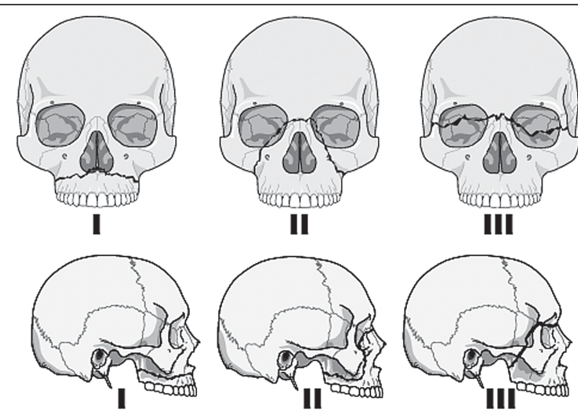
The maxillae bones are the largest bones of the face; together, they form the upper jaw. The maxilla (singular) consists of a body and four processes: zygomatic, frontal, alveolar, and palatine. The maxilla forms the hard palate, floor of the nose, part of the orbits, and the tooth sockets of the upper teeth.

Maxillary fractures are less common than mandibular fractures and are often associated with other facial fractures. Complaints such as, "My bite isn't right" are common as most maxillary fractures involve the dental occlusion. Children are much less likely to have maxillary fractures until age 10 due to the enhanced malleability of their bones and the stronger unerupted dentition.[12]

Classically, maxillary fractures are broken down into the Le Fort classification, which was created in 1900 by Rene Le Fort who used cadaver trauma to provide detailed descriptions of three basic types of midfacial fractures (**Figure 9**).

The ***Le Fort I*** fracture is a horizontal fracture above the roots of the teeth and extends from the piriform sinus of the nose to the pterygomaxillary fissure, separating the maxillary tuberosity from the pterygoid plates. The mobile fragment of maxillary bone is often likened to a loose upper denture, containing the teeth and palate. The fracture results from a horizontal blow applied to the anterior maxilla and can be a single fragment or comminuted fragments.

Figure 9. Le Fort Classification Of Maxillary Fractures



With permission from Richardson, Michael L., University of Washington, Department of Radiology. www.rad.washington.edu/mskbook/facialfx.html

The ***Le Fort II*** fracture courses upward through the infraorbital rim, through the medial orbit and the nasal bones. Since the fragment forms a triangular shape, this is often called a pyramidal fracture.

The ***Le Fort III*** fracture crosses the maxilla, naso-ethmoid complex, and the zygoma (**Figure 10**). This fracture is often termed a craniofacial dislocation or separation since the entire midface is now mobile. A complete bilateral Le Fort III fracture is rare and caused by massive trauma. Spinal fluid leakage is common. The remaining soft tissue attachments are often only the optic nerves, so gentle evaluation is appropriate.

A "simple" Le Fort fracture is actually uncommon for two reasons. First, rarely do fractures in the midface follow the suture lines describe by Le Fort. The fractures follow the path of least resistance and may be comminuted and multiple. In reality, the single-piece Le Fort fracture may be composed of multiple pieces with the nasal section or zygomatic section disconnected from the maxillary tooth-bearing fragment. Secondly, blows to the face are often from an angle, so that a facial fracture may have a Le Fort II component on one side and a Le Fort III component on the other side.

Frontal Bone Fractures

The frontal sinus ranges from negligible to filling the entire forehead region of the frontal bone. The forehead (*more properly:* the outer table or squama) and the zygomatic processes are very thick, consisting of diploic tissue contained between two compact laminae; the diploic tissue is absent in the regions occupied by the frontal air sinuses. The orbital portion is thin, translucent, and composed entirely of compact bone and mucous membrane. The outer table is thick and heavy. The inner portion of the inner table is lined with the dura mater of the meninges.

Frontal sinus injuries in both adults and children often result from blunt trauma, such as an unrestrained passenger hitting the dashboard or windshield in a motor vehicle collision.[36] Motor vehicle collisions are the leading cause of frontal sinus fractures, but this has decreased since the adoption of mandatory seat belt laws coupled with airbag technology.[9]

Figure 10. LeFort Facial Fractures Clinical

This is a photograph of a patient with blunt facial trauma. The patient demonstrates the classic "dish face" deformity (depressed midface) associated with bilateral LeFort III fractures. Reprinted from Schnarrs, Robert. Copyright © 2007 The McGraw-Hill Companies. All rights reserved.

When compared to other facial fractures, fractures of the frontal sinus are uncommon – probably due to the thickness of the bony ridges involved. The frontal sinus is fractured in 5-30% of patients who sustain maxillofacial injuries.[37] The frontal sinus is relatively resistant to fracture and a significant amount of force is needed for a fracture to occur. It takes about 800-1600 foot-pounds of pressure to fracture the anterior table of the frontal bone. In general, the greater the magnitude of force applied, the more likely that both tables of the bone will be broken. In one series, only 24% of patients were conscious at the time of initial evaluation.[38]

In general, repair of the posterior table is important for preventing central nervous system complications such as pneumocephalus or CSF leak.[37] Repair of the anterior table is important for cosmetic reasons.

Lacerations frequently accompany frontal sinus fractures and may obscure the deeper part of the injury. The examiner should be wary when dealing with a patient who has been struck in the forehead. These injuries should be carefully explored to ensure that any fractures are found. A CT of the head is indicated for complete evaluation, since patients can have a displaced posterior table fracture without palpable anterior fractures. Crepitus may be found when the patient has multiple fragments of bone that are mobile.

At birth, the frontal sinuses originate either as an expansion of the frontoethmoid air cells into the frontal bone or by superior extension of the frontal recess. The frontal recess represents the most anterior and superior portion of the infundibulum of the middle meatus. The frontal sinus is not pneumatized until the age of two and it can be first appreciated radiographically in individuals six to eight years of age. Pneumatization is often not symmetric and may be partial or incomplete in approximately 20% of adults. Adult size of the frontal sinus is attained between 15 and 19 years of age. Since the pediatric frontal sinus is often not present, fractures of the frontal sinus are nearly twice as common in the adult population than in the pediatric population.

Differential Diagnosis

Since the etiology of the injury is often known, the clinician is left with identifying what was injured and to what extent it was damaged. The differential diagnosis of facial trauma contains all of the fractures, soft tissue abrasions, contusions, and lacerations discussed in this monograph. The examiner must be careful not to stop the evaluation simply because one fracture or injury is noted. Multiple studies have shown that as many as 30% of patients have two or more fractures or injuries.

Prehospital Care

There is very little research on the prehospital care of the patient with maxillofacial trauma. When emergency services personnel are evaluating the patient, they need to ensure the ABC's of trauma care (as discussed in the next section). This is particularly important in the management of facial trauma where cervical spine damage can simultaneously occur with airway damage or impingement by swelling or significant bleeding.

ED Management

Upon arrival to the emergency department, the physician should re-evaluate the patient with the same four emergency steps recommended for prehospital providers (listed below).

Severe facial trauma often results in partial airway occlusion. The airway risk may increase due to bleeding, swelling in soft tissues, and hematoma formation. Patients with severe facial fractures may have decreased level of consciousness due to intracranial injury. While lifting the jaw and inserting an oral or nasal airway may temporarily help the situation, neck fractures are also common in these patients. Only when the patient's airway is stable, breathing is intact, bleeding has been controlled, and the cervical spine has been immobilized should the physician proceed in the secondary evaluation.

1. The physician MUST ensure an **airway** if this has not been done by prehospital providers.

   Airway compromise is common in persons with severe maxillofacial injures. Assess the patient for airway obstruction. Look for evidence of injury to the larynx and trachea, including crepitus of the surrounding soft tissues. Clinically, the patient may have noisy breathing, snoring, gurgling, or croaking. Remove foreign bodies with finger sweep, strong suction, or Magill forceps under direct visualization. After foreign bodies are removed, endotracheal intubation and assisted ventilation may be appropriate. In some patients, cricothyroidotomy or emergent tracheotomy may be necessary. (Emergent tracheotomy may be needed with an associated fractured larynx. Hoarseness, subcutaneous emphysema, and a palpable fracture are suggestive of laryngeal fracture.) Airway compromise may require an immediate operation to reduce the fractured facial bones that are impinging in the airway.

2. The physician MUST ensure that the patient is **breathing** and continues to breathe.

   Blood or edema resulting from the injury can cause upper airway obstruction. The tongue may obstruct the airway in a patient with a mandibular fracture. A fractured free-floating maxilla can fall back, obstructing the airway. Displaced tooth fragments can become foreign bodies in the airway.

3. The physician MUST assess the **circulation** and **control bleeding**.

   Blood is supplied to the midface region from the branches of the sphenopalatine artery and greater palatine artery as well as branches of the internal carotid artery (such as the anterior and posterior ethmoid branch of the ophthalmic artery). Assuming that coagulopathy is absent, severe bleeding resulting from maxillofacial trauma is rare and the source can often be properly controlled in the ED.

   Control of facial vascular injuries proceeds from simple direct wound pressure to vessel ligation for significant bleeding. Vessel ligation should only be performed under direct visualization of the bleeding vessel. Blind clamping can damage critical structures such as the facial nerve or the parotid duct. A Foley catheter placed into a wound and inflated may control bleeding from penetrating wounds.

   Oropharyngeal bleeding must be controlled to ensure that the airway remains patent. This bleeding is often from the nose and associated structures that drains through the posterior nasopharynx into the oral cavity.[40] Posterior nasal packing should be considered early in the control of oropharyngeal bleeding in any patient who has significant facial trauma. As mentioned, a nasal balloon or Foley catheter may be inserted into the cranial vault in a patient with severe facial trauma and basilar skull or cribriform plate fracture. If severe disruption of the hard palate or maxilla within the oral cavity occurs, control of the airway and packing of the oral cavity may also be required.

   Continued severe bleeding may require immediate surgery to ligate associated major vessels or to reduce broken facial bones and control hemorrhage. Transcatheter arterial embolization may be an alternative to surgical control of hemorrhage.[41] This requires an arteriogram to visualize the site of bleeding before introduction of the embolus.[40]

   Large open wounds should be debrided and closed in a layered fashion. This will both decrease blood loss and subsequent infectious complications. Wounds that may be used later for access to repair fractures may be closed in a temporary fashion.

4. The physician MUST assess for **neurological disability** and ensure that the patient's cervical spine is protected from further damage.

   During airway control, maintain cervical spinal immobilization in bluntly injured patients. Unstable cervical spine injury is quite rare in neurologically intact penetrating facial wounds, but up to 10% of patients with significant blunt facial injuries will also have cervical spine injury.[39]

Conversely, 15-20% of cervical spine injuries are associated with facial fractures.

History

Ask the responsive patient the following questions:

1. *Which areas on you face hurt?* Although this is a basic question, the presence of pain in a specific location can direct the examiner towards the site of a fracture. This question may not be as reliable in the intoxicated patient or the patient with multiple injuries.
2. *Are there any areas of numbness on your face*? Any sensory deficit may show where a facial fracture has occurred, and the fragments either impinge upon or have damaged the bony canals / grooves / foramina where the branches of the trigeminal nerve run.
   a. *Is your lip or chin numb*? The inferior alveolar nerve runs through the center of the mandible from the middle of the ramus to the mental foramen, where it exists to provide sensation to the lower lip and chin. If the patient feels numb on the lower lip or chin, it is likely that there is a fracture on the side of the numbness.
   b. *Is your cheek, upper lip, side of the nose, or upper gingiva numb*? The infraorbital and superior alveolar nerves provide sensation to the maxillary teeth and gingiva, the upper lip, the side of the nose, and the lower eyelid. If the patient has numbness here, it is likely that a fracture exists in the maxilla or orbital floor.
   c. *Is your lower eyelid, cheek, or upper lip numb*? The infraorbital nerve courses along the floor of the orbit. It is often disrupted by a zygomaticomaxillary complex fracture.
3. *Does your bite feel 'normal?'* Mandibular and/or maxillary fractures are commonly associated with the feeling that the bite is not 'normal.' The location of contact of the teeth can often help the clinician find the site of the fracture.
4. *Does it hurt when you open your mouth? Where does it hurt?* Pain when the patient attempts functional movements of the mandible can indicate the presence of fractures of the mandible or maxilla. Contusions of the mandible or the temporomandibular joint can also produce similar pain. For example, pre-auricular tenderness with mandibular movement can indicate a condylar process fracture. Pain in the area of the cheek when the patient attempts to open their mouth can indicate a zygomaticomaxillary complex fracture. Pain at the angle of the mandible can indicate a fracture in that area. The masseter muscle attaches to the body of the zygoma and inserts onto the mandibular ramus. When fractures of the zygomaticomaxillary complex occur, they cause contraction of the masseter muscle and subsequent trismus. Rarely, the zygoma can be displaced so that it impinges on the coronoid process of the mandible, limiting the opening of the jaw.
5. *Are you having trouble seeing?* If possible, pre-injury visual status should be reviewed with the patient. The state of the vision immediately after the trauma should also be determined. Loss of light perception that returns suggests either a vascular occlusion or an optic nerve contusion. Immediate and persistent loss of light perception implies severe damage to the retina or optic nerve. Initial good vision that deteriorates may suggest a compressive ocular neuropathy and constitutes an emergency. If the patient reports flashing lights or 'floaters,' a retinal tear or detachment or a vitreous hemorrhage should be suspected. Other ophthalmologic conditions to include in the differential are corneal abrasions, traumatic iritis, globe rupture, and lens dislocation. *See our September 2007 issue, An Evidence-Based Approach To Abnormal Vision, at www.ebmedicine.net/redirect/?topic=emp.*
6. *Do you see double?* The presence of diplopia can indicate a periorbital fracture with or without impingement of the extraocular muscles. It is a relatively non-specific symptom and can be caused by periorbital edema alone. If the patient notes diplopia, CT of the orbits/facial bones is indicated. Ocular symptoms of orbital facial fractures include orbital pain, enophthalmos, and vertical diplopia.
7. *Does your neck hurt?* This is not an unreasonable question given the association of facial trauma and cervical spine injuries.

If possible, the events that surround the injury should be obtained from the patient, the police, or EMS providers. Remember that the patient's account may differ from other potentially more reliable sources. This history can provide clues to the type of injuries that the patient has sustained. For example, blunt trauma to the face is more likely to result in fractures, while a sharp penetrating injury can injure nerves and major vessels. Interpersonal altercations tend to result in a higher incidence of nasal, blow-out, and mandibular fractures, while motor vehicle accidents result in more serious trauma. Heightened concern for serious injury should be present when evaluating the patient who has had a high velocity blow to the face, such as a baseball, baseball bat, or golf club impact.

Past medical history should always be assessed when possible. Look for seizure disorders, alcohol abuse, prior head and neck trauma or surgery, temporomandibular joint problems, and nutritional or metabolic derangements. Use of 'blood thinning' agents such as aspirin, warfarin, clopidogrel (Plavix®), or enoxaparin (Lovenox®) should always be ascertained as these agents may increase bleeding both in the wounds and within the skull.

Physical Examination

A careful physical examination is paramount for the diagnosis of craniofacial injury, since additional and potentially life-threatening injuries are not uncommon. During this initial survey, life-threatening injuries and systemic medical problems should be addressed.

The airway is the first critical injury that may be associated with facial trauma. The patient who has sustained a maxillofacial fracture may have airway compromise due to loss of tongue support secondary to facial fractures or obstruction of the airway due to blood or debris. The unconscious patient with significant facial trauma needs rapid sequence intubation or a surgical airway as indicated by the patient condition and ease of intubation. This intubation should be performed with appropriate cervical spinal precautions.

The patient who has sustained a significant facial fracture should be assumed to have an associated cervical spine injury. Studies have shown that approximately 10% of patients with facial fractures have injuries of the cervical spine. Suspicion of concomitant spinal injury can range from low in the isolated nasal fracture from a blow to very high in the complex facial fracture sustained in a high-speed motor vehicle accident.

Once the patient's airway, breathing, and hemodynamic status have been stabilized and the patient has been evaluated for cervical spinal trauma, perform a systematic secondary survey. Determine and appropriately manage the tetanus status of all patients. Gently remove dried blood and foreign bodies from wound sites in order to evaluate the depth and extent of the injury.

As always in the trauma patient, seek associated injuries. The patient with facial injuries often has an altered sensorium and may not relate such details as sustaining a fight bite laceration to the hand. A comprehensive physical examination to ensure that no significant other lesions are missed is not just 'nice to have'… it's imperative.

Examine the patient for dental trauma and malocclusion.[42] Examine the oral cavity for lacerations, penetrating injuries, and continuing bleeding. The tongue is frequently lacerated in facial trauma and can produce both airway compromise with swelling and significant bleeding. Explore soft tissue injuries within the oral cavity for tooth fragments and other foreign bodies. Note areas of ecchymosis and facial swelling.

Evaluate the dentition and account for all empty tooth sockets. Teeth can be displaced into soft tissues, pushed into the socket, avulsed with subsequent aspiration, swallowed, or left at the scene. Any missing teeth require a chest x-ray to ensure that a tooth has not been aspirated. Evaluate the dentition for mobility which would indicate an underlying alveolar fracture. The presence of a step-off or irregularity of the dentition may indicate an underlying fracture. The presence of blood at the gingiva should also prompt a search for underlying fracture. Frequently, hematomas on the lingular side of the jaw may extend into the floor of the mouth, causing discoloration and swelling of the floor of the mouth. Check for stability of the teeth in both the upper and lower jaw.

The clinical examination of the face begins with a detailed examination of the area for localized tenderness, numbness, bleeding, deformity, ecchymosis, periorbital edema, otorrhea, rhinorrhea, and facial asymmetry.[43] Facial asymmetry is often easiest to examine by looking down from the head of the bed. The superior and inferior orbital rims, zygomatic arches, nose, maxilla, mandible, and both alveolar ridges should be palpated and evaluated.

Zygoma fractures commonly present with periorbital ecchymosis, lateral subconjunctival hemorrhage, infraorbital hypoesthesia, bony step-off of the orbital rim, and depression of the malar eminence. Displacement of the bone medially may impinge on the coronoid process of the mandible, resulting in trismus. Most zygomaticomaxillary fractures occur through the frontozygomatic suture, and a step-off may be found at the junction of the superior one-third and inferior two-thirds of the lateral orbital rim.

A depression of the malar eminence with tenderness suggests either a zygoma, zygomatic arch, or tripod fracture. A zygomatic arch fracture can be clinically difficult to find as the only sign may be a depression of the arch or a decreased range of mouth opening. The patient may have marked edema due to the associated soft tissue trauma, so the depression may be obscured. The patient may note pain in the cheek, pain in the cheek on movement of the jaw, or trismus. Trismus may be marked when the zygomatic fracture impinges on the temporalis muscle. A flat malar arch may best be assessed by palpation from behind the patient's head or viewing the supine patient from above the patient's head. Compare symmetry with the opposite side.

Suspect a tripod fracture after a blow to the cheek resulting in marked periorbital edema and ecchymosis. There may be flattening of the malar eminence, but resultant soft tissue trauma can obscure the flattening.

If the zygoma is displaced inferiorly, it may cause depression of the lateral canthus. When the fracture extends through the orbit, the infraorbital nerve may be damaged or bruised which results in hypesthesia of the distribution of the infraorbital nerve.

If the examiner palpates the zygomaticomaxillary arch from within the mouth, a step-off may be found. Another step-off point is at the zygomaticofrontal suture or on the zygoma.

Closely examine the eyes, even if the eye is swollen shut. Check for injury, abnormality of ocular movements, and visual acuity when possible. Eyelid ecchymosis, subcutaneous emphysema, ptosis, epistaxis, lacrimal system injuries, and pupillary dilation may each be associated with facial fractures. Pay special attention to assessing extraocular motility for extraocular muscle entrapment and to ensure that there is no orbital compartment syndrome present.[25]

Whenever there is enough lid swelling or periorbital edema to restrict voluntary eyelid opening, use great caution. Consider the mechanism of injury and search for a penetrating wound. The presence of hyphema, vitreous hemorrhage, or inability to visualize the fundi should prompt an urgent ophthalmologic consultation. If there is a through and through lid laceration, call the ophthalmologist to repair the tarsal plate which gives structure to the lids.

Midface stability should also be evaluated. This can be accomplished by grasping the teeth and hard palate and gently pushing back and forth and then up and down. Look for movement or instability of the midface. If mobility is detected, determine the level of the fractures by palpating with the other hand on the face over the bridge of the nose, the infraorbital rims, and along the zygoma.

A Le Fort I fracture includes facial edema and mobility of the hard palate. Grasp the incisors and hard palate and gently push in and out. In a Le Fort I fracture, these structures will move.

A Le Fort II fracture has marked facial edema, bilateral subconjunctival hemorrhage, and mobility of the maxilla. Telecanthus is usually appreciated. The patient may have either epistaxis or CSF rhinorrhea. If the nasal bridge moves along with the maxilla, a Le Fort II fracture should be suspected

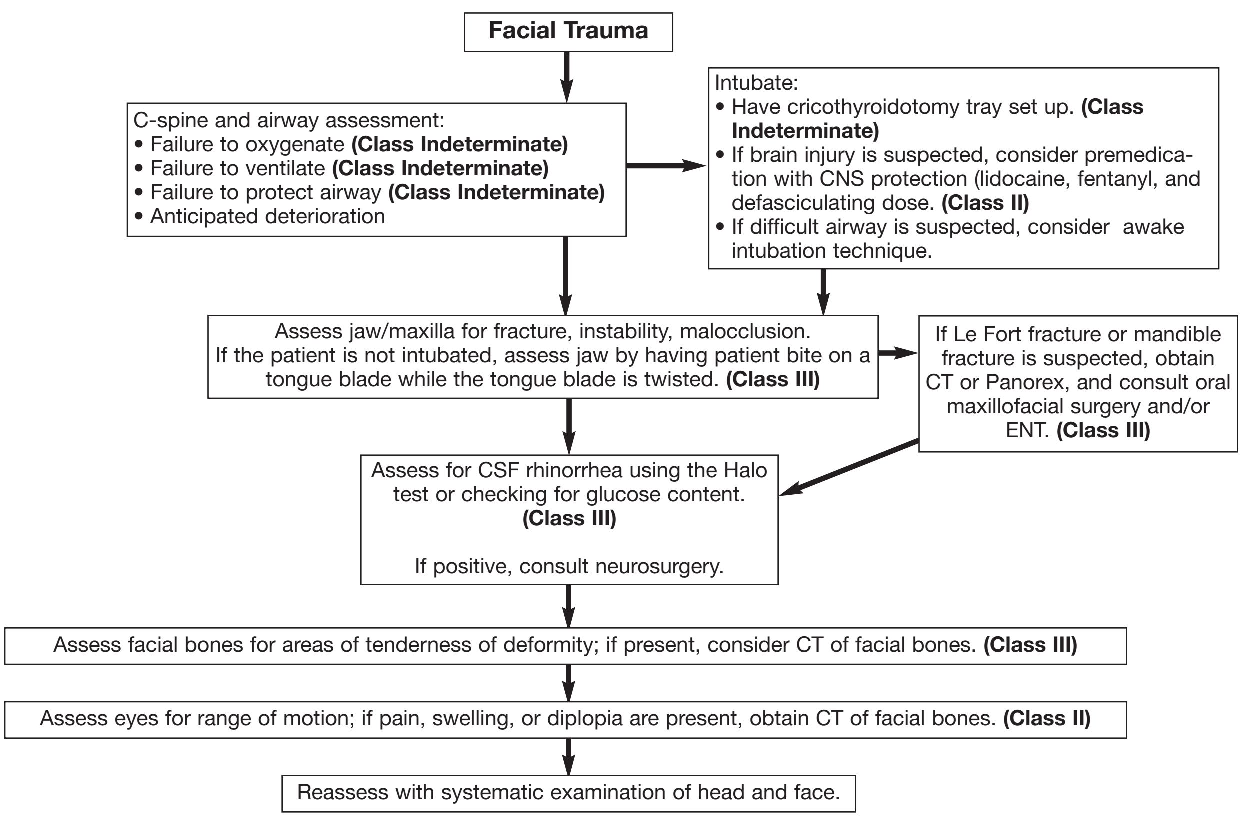
A Le Fort III fracture has facial flattening and elongation. The maxilla may be displaced posteriorly, leaving the mouth open. Grasping the anterior teeth and moving them will result in movement of the entire front face (craniofacial dislocation). CSF rhinorrhea and epistaxis are likely both present. If the nose, infraorbital rims, and the zygoma move together with the maxilla, a Le Fort III fracture is probable.

The physical examination should involve both internal and external evaluation of the nose, regardless of the mechanism of injury. Palpate the nose for tenderness and crepitus. Clinical evidence of a nasal fracture includes swelling, tenderness, deformity, epistaxis, crepitus, nasal airway obstruction, and periorbital ecchymosis. In examination of the nose, note the degree of bony deformity (laterally or depressed) as well as the presence of cartilaginous deformity and associated soft tissue injury (such as mucosal laceration, soft tissue swelling, epistaxis, septal or orbital hematoma, and subcutaneous emphysema).

Inspect the nasal septum for septal hematoma. A bulging, bluish, tender septal swelling or mass indicates a septal hematoma and requires evacuation of the hematoma.

Examine the nose for CSF fluid. The presence of CSF rhinorrhea indicates disruption of the base of the skull, most commonly at the cribriform plate of the

Clinical Pathway: Facial Trauma



ethmoid bone (associated with a naso-ethmoid fracture or from disruption of the posterior wall of the frontal sinus). An alternative site is a basal skull fracture or temporal bone fracture that leaks into the middle ear and then drains through the eustachian tube into the nose.

Look at the nose for telecanthus and widening of the nasal bridge. Widening of the intercanthal distance (> 40 mm) suggests the possibility of a naso-orbito-ethmoid fracture.

A frontal laceration should make the examiner particularly suspicious of an underlying fracture in the patient who has been involved in a motor vehicle collision. The laceration must be carefully examined for a bony step-off. The orbits should also be carefully evaluated. The deformity of a fracture is often hidden by edema, so the physical examination alone may not be sufficient in the patient with substantial forehead lacerations.

Fractures of the mandible present in different fashions depending on the location and the severity of the injury. A fracture can be obvious if it has a large degree of displacement and has caused lacerations in the mucosa or skin. During the examination, look for signs of asymmetry and swelling. The most common presenting symptoms of patients with mandibular fractures are pain and malocclusion. Additional signs and symptoms include intraoral bleeding, lower lip and chin hypoesthesia or anesthesia, trismus, deviation with jaw movement, swelling or hematoma of the floor of the mouth, and ecchymosis of the gingiva.[43,44] Although a sublingual hematoma is not a consistent finding, it is strongly suggestive of a mandibular fracture when present. Any of these findings should prompt the examiner to obtain further radiographic studies.

Occasionally, a patient will have a widened appearance to the face. This may occur when both condyles are fractured combined with a fracture of the symphysis allowing the mandible to open like a book.

For the tongue blade test (TBT), have the awake patient grip a tongue blade with his/her teeth and then break it by rotation (twisting).[45] If the patient is able to do this on both sides of the jaw, it is unlikely that a mandibular fracture exists.[46] This test has been shown to be 95.7% sensitive if the patient can break the blade without pain.[45]

The external auditory canal can occasionally be damaged by a fracture of the mandible, so the canal should be visualized bilaterally in patients who have had trauma to the jaw. The temporal-mandibular joint (TMJ) can be felt by placing a finger into the ear canal and pressing forward (anteriorly). This may be more sensitive than palpation of the TMJ in the preauricular area. If the patient has no pain here, fracture is less likely.

In the conscious and cooperative patient, a detailed cranial nerve (CN) examination should be performed.[47] The optic nerve (cranial nerve II) can be assessed by having the patient read and by visual field acuity. Extraocular movements test the integrity of CN III, IV, and VI.[48]

Evaluate the supraorbital, infraorbital, inferior alveolar, and mental nerve distributions for hypesthesia or anesthesia. Hypoesthesia of the face suggests cranial nerve V injury. Injury of the facial nerve (CN VII) produces paresis or paralysis of the muscles of facial expression.

The cranial nerve examination of the unconscious patient is more difficult and relies on the testing of brain stem reflexes.[47] Assessment of vision can be quite difficult. Pupillary reflexes may remain intact as long as the efferent pathway of cranial nerve III is intact, even when complete unilateral vision loss is present.[49] Evaluation of the CN II pathway and the efferent CN III parasympathetic pathway is possible in the unconscious patient with the swinging flashlight test. Testing patients with unilateral afferent CN II damage reveals bilateral equal papillary constriction when the flashlight is directed towards the eye with remaining vision. When the light is directed towards the damaged eye, both pupils will dilate. This is the Marcus-Gunn pupillary reflex.[49] *See Volume 9 Number 9, An Evidence-Based Approach To Abnormal Vision, for a complete description of this test.*

In the unconscious patient, extraocular movements can be tested with the doll's eye reflex (oculocephalic reflex). Testing of the gag reflex evaluates CN IX and CN X. The ice-water caloric test evaluates the function of CN VIII. To perform this test, wash the auditory canal and tympanic membrane with iced water; this will cause the patient to develop nystagmus. This test should not be performed when there is a rupture of the tympanic membrane. The corneal reflex tests the afferent fibers of CN V and the efferent fibers of CN VII. For this test, touching the cornea with a small wisp of cotton causes the eyelid to close.

Laboratory Analysis

Distinguishing between CSF and serous nasal secretions may be difficult. Blood from head injured patients may mix with CSF and mask the recognition of a leak. The simplest tests for CSF fluid are easy to perform but are not very accurate. If a sufficient sample of nasal drainage can be obtained, it can be sent to the lab and analyzed. CSF is odorless, salty, and has a specific gravity of 1.006. The protein level is much less than nasal fluid, while the chloride level is greater. More importantly, CSF has a greater concentration of glucose than mucus or lacrimal secretions. The quantitative determination of a glucose level in nasal fluid not contaminated by blood can be diagnostic of CSF rhinorrhea if the nasal fluid contains more than 30 mg/dL. Negative test results for glucose virtually eliminate the possibility of CSF. CSF will separate from blood when the mixture is placed on filter paper, resulting in a central area of blood with an outer ring or halo. Blood mixed with tap water, saline, and rhinorrhea fluid also produces a ring. The halo sign does occur, but clearly does not clinch the diagnosis. Another simple test involves collecting rhinorrhea on a handkerchief. Nasal secretions will dry and leave a stiff residue, whereas CSF will dry and leave the cloth soft. This test depends on the lower protein level found in CSF. Glucose oxidase paper or dextrose sticks have historically been used to identify CSF. However, they have been shown to be unreliable because lacrimal gland secretions and nasal mucus have reducing substances that may cause a positive reaction with glucose concentrations as low as 5 mg/dL. The gold standard for laboratory diagnosis of CSF fistulae is beta-2-transferrin. This protein is found in only three bodily fluids – CSF, perilymph, and vitreous humor. Therefore, production of clear nasal discharge that is positive for beta-2-transferrin is highly diagnostic for CSF. Unfortunately, this test requires electrophoresis and often takes about four days for results.

Diagnostic Imaging Studies

After the patient has been stabilized and examined, appropriate radiographs and computerized tomograms (CTs) can be obtained. A patient with suspected cranial trauma should have CT scans of the brain as well as facial bone-specific radiographs and CTs. If there are obvious or suspected facial fractures, an appropriate approach would be to obtain axial cuts from the top of the skull through the entire cervical spine. Current generation spiral CT scanners can perform such an examination within minutes. Reconstruction of the films with computer-generated three-dimensional imaging allow examination of the entire face.

Radiographs

A basic facial series consists of three or four films: a Waters view (PA view with cephalad angulation), a Caldwell view (PA view), a lateral view, and a submentovertex view occasionally. If a nasal fracture is suspected, then a lateral view of the nasal bone with special nasal technique may be done. Of these views, the most consistently helpful view in facial trauma is the Waters view. It tends to show all of the major facial structures at least as well and often better than other radiographic views of the face.

There are some suggestions that help with interpretation of the facial bone series.

1. Look at the orbits…carefully! Sixty to seventy percent of all facial fractures involve the orbit in some way. It is important to look carefully at the orbital borders and apex as well as the optic canal. Exceptions include:
   a. A localized nasal bone fracture
   b. A zygomatic arch fracture
   c. A LeFort I fracture
2. Know the *common* facial fracture patterns and look for them.
   a. Zygomaticomaxillary complex fracture (tripod fracture)
   b. LeFort I, II, and III
   c. Zygomatic arch
   d. Orbital blow-out fracture

   On a Waters view, the examiner may see a soft tissue mass on the superior margin of the maxillary sinus, representing the herniated intraorbital soft tissues protruding into the maxillary sinus. A trapdoor fragment of bone may be seen protruding into the sinus, often hinged on the ethmoid side. CT of the orbit will show these abnormalities much better.

   e. Alveolar process of the maxilla
3. Look at both sides of the facial films … bilateral symmetry is a friend.
4. Direct signs of a fracture:
   a. Nonanatomic linear lucency
   b. Cortical defect or diastatic suture
   c. Bone fragments overlapping, creating a radiographic double density
   d. Asymmetry of any part of the face (symmetry is a friend)
5. Indirect signs of a fracture:
   a. Soft tissue swelling
   b. Periorbital or intracranial air
   c. Fluid in a paranasal sinus

Radiographic Views Of The Nose

The use of x-ray to evaluate the patient with simple nasal trauma is of limited value as decisions regarding the treatment of nasal trauma are based on clinical findings.[15,50,51] A plain nasal bone view cannot be reliable in exclusion of a naso-ethmoid fracture and CT scan is therefore appropriate with persistent epistaxis, CSF rhinorrhea, or both.

If deformity persists after the resolution of the edema, films may be ordered at follow-up examination to help plan the repair. This would not be the usual responsibility of the emergency physician. Omission of nasal films is cost-effective, since most nasal fractures will need no reduction.

Although isolated nasal fractures do not generally require radiographic studies, it is appropriate to order a CT scan after a thorough history and physical examination when other facial fractures are suspected. Three-dimensional reconstruction may help the consultant plan surgical repair.

Radiographic Views Of The Orbit

The degree of orbital floor displacement and the presence of soft tissue protruding through a fracture are diagnosed accurately with coronal CT scans of the orbit and facial bones. Axial scans are useful but are not as accurate. Surgical intervention may be indicated when there is significant orbital floor disruption, entrapment, enophthalmos, or persistent diplopia.[47]

Radiographic Views Of The Zygoma

Zygomatic arch fractures can be seen on the underexposed submental view (sometimes called a bucket-handle view). In this view, the arches will appear like bucket-handles, hence the nickname. A zygomatic arch fracture can also be seen on Water's view, a

Towne view, or the facial series.

If a tripod fracture is suspected, obtain the Water's view, Caldwell view, and the bucket-handle view. The Caldwell view evaluates the zygomaticofrontal suture and the frontal process of the zygoma.

If at all possible when dealing with a suspected orbitozygomatic fracture, obtain a CT of the area. Although the Water's view may show some signs of a fracture, plain films are considered inadequate for evaluation of a fracture of the zygoma.[56]

Radiographic Views Of The Mandible

The mandibular series of radiographs consists of two lateral oblique films, a reverse Towne's view, and an anterior-posterior projection. The Towne's view is an AP view with the neck flexed forward. It is best to visualize condylar regions and the ascending rami of the mandible; a PA view is helpful in seeing the mandibular symphysis. In cases where missing teeth are unaccounted for, perform a chest x-ray to evaluate for aspiration. Cervical spine fractures are present in approximately 2% of patients with mandibular fractures and should be evaluated routinely.[28]

Condylar and coronoid fractures are more difficult to detect than those in other areas of the mandible.

When the mandible is injured, it behaves as if it were a complete ring. The ring is rigid and connected at each end to the skull by a firm joint. If one fracture of the mandible is found in a radiograph, another fracture or dislocation is quite likely to be present. Fractures of the angle of the mandible on one side will often have a fracture of the mandibular condyle on the other side.

The single most informative plain film radiologic study used in diagnosing mandibular fractures is the panoramic radiograph (**Figure 11**).[52] When the panoramic radiograph is compared with simple radiographs, it is clear that the panoramic radiograph is superior to the plain film radiograph for diagnosis of mandibular fractures.[53,54] In one study, the panoramic radiograph was shown to diagnose 92% of fractures of the mandible.[28] The panoramic radiograph provides the ability to view the entire mandible in one radiograph.

The utility and accuracy of CT depends upon the generation of the machine and the techniques used. If available, helical CT scanning may have enhanced imaging quality and equivalent sensitivity in the identification of mandibular fractures. Spiral scanning machines are significantly more accurate than older machines and may replace the panoramic radiograph as the diagnostic tool of choice.[55] In fact, helical computed tomography was 100% sensitive in diagnosing fractures of the mandible compared with a Panorex, which was 86% sensitive.[28] On the other hand, another study showed that the number and anatomical location of mandible fractures identified by helical CT and panoramic tomography were not significantly different.[70]

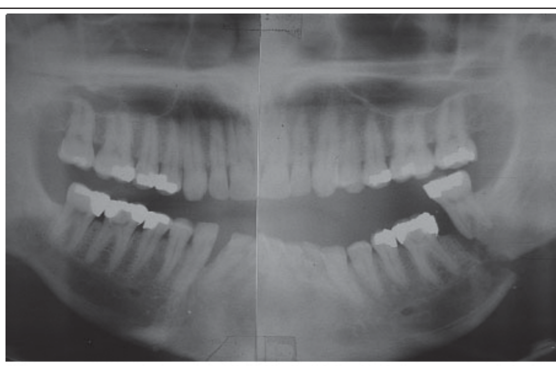
Radiographic Views Of The Maxilla And Midface

The midface skeleton is much more difficult to assess using plain films than is the mandible. The presence of very thin bones, fluid-filled sinuses (congestion vs. blood), and soft tissues make accurate assessment problematic. Diagnosis of all midface fractures has been enhanced by high-resolution CT scanning. Axial and coronal CT scans with thin cuts of the facial bones are recommended for all of these fractures **(Figures 12 and 13)**.

Radiographic Views Of The Frontal Bone

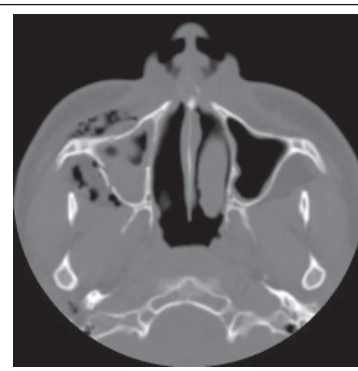
A CT of the head is indicated for complete evaluation of a frontal bone injury, since patients can have a displaced posterior table fracture without palpable anterior fractures. Crepitus may be found when the patient has multiple fragments of bone that are mobile. CT's not only allow the evaluation of the anterior and posterior table of the frontal bone, they allow the examiner to evaluate for fluid within the sinuses, the presence of intracerebral injuries or air within the cranial cavity, and associated facial fractures.

Figure 11. Panoramic View Of An Unfavorable Mandibular Fracture Dental



This demonstrates a mandibular fracture with obvious misalignment due to the distracting forces of the masseter muscle. Reprinted from Amrhein, Edward S. Copyright © 2007 The McGraw-Hill Companies. All rights reserved.

Figure 12. Axial CT Of The Maxilla



This image through the maxillary sinuses reveals a fracture of the right wall of the right maxillary sinus, the source of the emphysema. Reprinted with permission from Gentili, Amilcare, UCSD Department of Radiology. Maxillary Sinus Fracture. Available at: http://www.gentili.net/image.asp?ID=917448377&imgid=Ctorbit2.jpg&Fx=Maxillary+Sinus+Fracture. Accessed 19 December 2007.

Special Considerations

Occult Mandibular Fractures

In the awake patient, abnormal dental occlusion indicates a probable fracture of the mandible.

Pediatric Injuries

An important difference between pediatric facial fractures and adult facial fractures is that injuries can result in growth dysplasias in children. Facial fractures in children are often missed on standard facial radiographs. The locations of fractures most likely to be missed in pediatric facial bone studies are the ethmoid and sphenoid bones (~100% missed), the maxilla (~88% missed), the zygoma (~86% missed), and the orbits (~75% missed).[13] Fractures of the frontal bone (38% missed) and the mandible (50% missed) are less likely to be missed. A CT scan of the facial bones is more important in children due to this higher likelihood of a missed fracture on plain film x-ray.

Orbital Compartment Syndrome

The presence of a retrobulbar hemorrhage (orbital compartment syndrome) is an acute emergency requiring immediate care.[25] The tearing of blood vessels within the orbit with resultant dissection of blood into the retro-orbital area causes an acute increase in the volume of the orbital contents. The volume increase transmits pressure to the globe, causing increased intraocular pressure. The eye becomes proptotic, with hemorrhagic swelling of the conjunctivae. Ocular motility is limited and vision may be compromised. If initial medical management does not result in improvement, the emergent surgical treatment of choice is a lateral canthotomy by slitting the lateral canthal tendon to decrease the orbital pressure. Most likely, the most important factor in determining the outcome in cases of retrobulbar hemorrhage is recognizing the condition as early as possible and instituting treatment promptly.

Naso-Orbital-Ethmoid Fracture

If the inter-canthal distance in an adult is more than 40 mm (about the width of the patient's eye), evaluate the patient for a possible naso-orbital-ethmoid fracture.

Continued Epistaxis Vs. CSF Rhinorrhea

Bleeding from the nose that continues beyond the immediate post-injury time may require the insertion of nasal packing or other commercially available devices, such as a hemostatic balloon or Mycelex sponge. The first step should be removal of the clot and the application of a topical vasoconstrictive agent.

Be sure that the bleeding is not CSF rhinorrhea. For CSF rhinorrhea to occur, trauma to the anterior cranial fossa must disrupt the dura and fracture the bone. The incidence of meningitis following a CSF rhinorrhea is small and use of antibiotics is controversial.[71] To the authors' knowledge, no prospective controlled study has been conducted to resolve this question. In light of the best available evidence, the routine use of prophylactic antibiotics is probably not indicated, and this practice may select out resistant organisms. The decision to use and the choice of antibiotics is usually left to the consulting neurosurgeon.

Cutting Edge Controversies

Mandibular Fractures – CT Or Panoramic Film?

The superiority of panoramic films over CT has been

Figure 13. CT Of A Maxillary Fracture

(A) Axial CT scan. Note that determining whether the vertical buttresses have been compromised is difficult using the axial image. (B) Coronal CT scan. This view demonstrates fractures through the nasomaxillary and zygomaticomaxillary buttresses. (C) Coronal CT scan. This more posterior view demonstrates fractures through the pterygoid plates. Image reprinted with permission from eMedicine.com, 2007. Available at: http://www.emedicine.com/plastic/topic481.htm.

questioned, and this may no longer be completely accurate for all CT machines.[55] The utility of CT depends upon the generation/techniques used. Spiral scanning machines are significantly more accurate than older machines and may replace the panoramic radiograph as the diagnostic tool of choice.[55] There is no question that fine-cut (1-3 mm) CT scanning will delineate mandibular fractures. In one study, the helical computed tomographic scan was 100% sensitive in the diagnosis of mandibular fractures, compared with a Panorex which was only 86% sensitive.[57] The fractures missed by the Panorex were generally in the posterior mandible. However, this study suggested that a dental root fracture may be better visualized by Panorex, particularly when the fracture is located in the angle.

A disadvantage of the panoramic radiograph is that it may not be available in some emergency departments. Additionally, a panoramic radiograph requires an upright patient, which renders it unsuitable for unstable trauma patients.[58] It also lacks fine detail in the temporomandibular joint (TMJ), symphysis, and dental/alveolar process regions with resulting missed fracture rates of about 8%.

A maxillofacial CT may be useful in mandibular fractures if the patient has multiple midface injuries, is in a cervical collar, or cannot otherwise undergo panoramic radiography.[55] This study will be significantly more expensive than the panoramic film. A CT of the head is obligatory if the patient has sustained a loss of consciousness due to trauma that results in a mandibular fracture. CT scanning with a spiral scanner can yield information in three-dimensional reconstructions.

The question (and controversy) is which is the most cost-effective and reliable study. Since the studies comparing the two diagnostic techniques have relatively low numbers, it is entirely possible that the two techniques remain equivalent. In this case, the best test is suggested by other factors, such as mobility of the patient, associated injuries, and cost.

Clinical Examination Of The Nose Or Radiographic Imaging?

Simple nasal fractures from isolated nasal trauma frequently require no immediate intervention, unless there is profuse epistaxis. Displaced fractures are treated by open or closed reduction of the fractured bones and/or the septum into correct anatomic positions up to 5-10 days after the fracture in adults and 3-7 days in children.[59] A major controversy (not discussed in this monograph) among plastic and otolaryngologic surgeons is the utility of open vs. closed reduction of the nose.[59,60] The use of x-rays in patients with simple nasal trauma is common in some centers but is of limited value.[15]

In isolated nasal trauma, radiographs have a high number of false-negative results and a large but unknown number of false positive results. Multiple studies have shown that radiographs do not help the clinician when a nasal bone fracture alone is suspected.[50,61]

History taking and the physical examination appear to be the best diagnostic tools for diagnosing nasal fractures and determining which nasal fractures require treatment by a consultant. Clinical evidence of a nasal fracture includes swelling, tenderness, deformity, epistaxis, crepitus, nasal airway obstruction, and periorbital ecchymosis. Nasal bone films should be abandoned as a clinical diagnosis is sufficient for accurate treatment.[51,62]

Should Nasal Intubation Be Used In Suspected Facial Fractures?

Nasal intubation has several advantages during repair of facial trauma. It will allow approximation of occlusion and intraoral surgical repair of lacerations and fractures. It may be tolerated longer than oral intubation in patients with associated trauma. However, controversy has surrounded nasal intubation in the presence of facial trauma for some time. The risk of penetration of the cranial vault has been the main concern regarding this procedure. Theoretically, a fracture could allow passage of the tubes into the cranium, although a review of the literature showed this risk to be low.[63-65] Marlow et al found only two documented cases of intracranial placement of an endotracheal tube.[63] While it can't be routinely recommended, it may be useful in select patients.

Intracranial placement of nasogastric tubes has been reported multiple times;[65] for this reason, passage of a nasogastric tube should NOT be done.[66]

There is only one reported occurrence of an intracranial placement of a nasopharyngeal airway.[67]

Use of a fiberoptic device may prevent possible passage into the cranial vault. The fiberoptic bronchoscope/laryngoscope with a tube over the scope may prevent a disaster and — where available — should be used if nasal intubation is contemplated. This technique is not feasible if visualization is obscured with secretions, blood, or swelling.

Patients with CSF rhinorrhea should be presumed to have cribriform plate damage; therefore, they are at increased risk if any nasal tube is passed, whether a nasal endotracheal, nasopharyngeal, or naso-gastric intubation.

If the trauma involves both the mandible and the upper face and the cervical spine is still considered 'at-risk,' a surgical airway may be more appropriate. If the cervical spine has been adequately evaluated, oral intubation may be more appropriate. Recent anesthesia literature has advocated the "submental" approach for endotracheal intubation in facial trauma.[68] Since this requires oral intubation prior to pushing the end of the endotracheal tube through a submental incision, it would not constitute an emergency airway technique.

Should Antibiotics Be Used For Facial Fractures?

Mandibular and sinus fractures are essentially open fractures that should be considered contaminated. Fractures of the mandible that are in a tooth-bearing region are compound fractures, even if non-displaced. Because bacteria from the mouth and saliva bathe the surfaces of the fracture until the soft issues heal enough to seal the wound, most clinicians recommend immediate prophylactic antibiotics. This may be changing. A recent prospective study showed no difference in the rates of wound infection in uncomplicated mandibular fractures with intraoral extension who received antibiotics versus those who received placebo only.[34] There is no comparable study for other facial or sinus fractures regarding the use of antibiotics.

Less controversial indications for peri-operative antibiotics include heavily contaminated fractures, severely lacerated soft tissues, severely comminuted fractures, and delayed fracture treatments. Prophylaxis should be considered in patients who have valvular heart disease or prosthetic implants.

Disposition

Definitive repair of most facial fractures is not a surgical emergency, and treatment is often delayed in the patient with multiple injuries. A recent study comparing patients undergoing repair within three days of a mandible injury to those repaired after three days found no increase in complication rates.[32] With the exception of fractures that significantly alter normal dental occlusion or compromise the airway (mandibular fractures and some maxillary fractures), repair of facial fractures may be delayed for as much as two weeks. After concomitant injuries and comorbid conditions are evaluated, treatment planning can begin. The timing of the repair may be left to the consulting surgeon.

Consultation

All patients with visual acuity changes associated with mid-facial fractures should have a consultation with ophthalmology,[49] as 28% of patients with midfacial fractures have moderate to serious eye injuries.[69] Minor or transient eye injuries, such as corneal abrasion, mild impairment of visual acuity and accommodation, and orbital emphysema, were found in 63% of patients. If there are any significant or questionable findings in patients with facial fractures, ophthalmologic consultation should be obtained. If the globe is proptotic and tense, a retrobulbar hematoma and subsequent orbital compartment syndrome should be suspected.

Patients with complex facial fractures or displaced fractures of the nose, zygoma, frontal, or orbital

Risk Management Questions For Maxillofacial Trauma

1. **Did you get a cervical spine film?**
   Although most facial fractures are in fairly thin and fragile bones, significant force may be applied to the head and transmitted along the cervical spine. Consider a cervical spine series even when the patient is alert and talking.
2. **Is alcohol the ONLY reason for the patient's altered sensorium?**
   Head trauma may be associated with facial trauma and the patient usually warrants a head CT. If the patient is intoxicated, check for other etiologies.
3. **If there is a frontal sinus fracture, did you check for underlying cerebral bleeding?**
   When the thick frontal bone is broken, underlying cerebral trauma is common.
4. **Did you note the diplopia?**
   Diplopia after facial trauma is a complaint that warrants a careful neurologic examination and facial bone CT to examine for orbital fractures, masses, and displacement.
5. **Did you check for orbital compartment syndrome?**
   After life-saving measures, maintenance of vision is the next most important goal in the care of the patient with maxillofacial trauma. Expanding hematoma in the orbit can jeopardize vision in the eye with an orbital compartment syndrome. If the globe is proptotic and tense, a retrobulbar hematoma and subsequent orbital compartment syndrome should be suspected. Urgent ophthalmologic consultation is indicated.
6. **Did the patient have a nasal septal hematoma?**
   A septal hematoma can be disfiguring and should be sought/noted in the chart.
7. **Is the missing tooth aspirated?**
   A chest x-ray is appropriate when your patient has a missing tooth. Check an abdominal film to ensure that the tooth was swallowed.
8. **Is the discharge from the nose epistaxis or CSF rhinorrhea?**
   CSF rhinorrhea is common with a nasal ethmoid fracture. It requires neurosurgical consultation.
9. **Did you note the depression of the zygoma and underlying zygomatic arch and orbital/maxillary complex fracture?**
   Facial edema can mask these injuries easily. If the patient has significant facial edema, be sure to get facial bone x-rays or CT.
10. **Did you look for the fight bite injury to the hand?**
    Remember to look for associated injuries. It is not at all uncommon for the recipient of facial trauma to defend him/herself and sustain a tooth-induced laceration to the hand that requires surgical debridement.

fractures should have prompt consultation with an oral surgeon, otolaryngologic surgeon, or plastic surgeon that performs this kind of surgery.

Patients with multiple trauma and/or significant co-morbidities should have consultation with the trauma surgeon.

Admission

Most patients with complex facial injuries will be admitted to the hospital. Underlying co-morbidities, ingestion of recreational drugs and/or alcohol, and additional concomitant injuries and mechanisms of injury will drive admission to the hospital for those patients with other associated problems. The awake patient with responsible home care and isolated mandibular or nasal injuries may be safely discharged.

Follow-up

Facial fractures become difficult to move by 7-10 days and are fixed by 2-3 weeks. This may happen sooner in children. Follow-up for facial fractures should occur within this time.

Discharge Instructions

Be sure to tell the patient to expect swelling of the injured areas. Advise them that this can best be handled with ice to the area and elevation. Nasal spray or similar medications may be used to decrease swelling within the nares and to allow better breathing. Sleeping in an upright position may also decrease swelling. Remind the patient to avoid laying on the injured areas or applying pressure to these areas.

Case Conclusion

4:10 a.m. Saturday morning: You just finished the evaluation of your 19-year-old 'guest' with significant facial trauma from the 'remedial correction' process at the bar. The patient's airway was clear, no CSF was noted, and there weren't any septal hematomas. Although you were prepared to insert a pack after examination of the nares to control the epistaxis, it resolved spontaneously. The neurological examination showed diplopia which you felt would be due to a blow-out fracture. Due to the altered sensorium, you immediately proceeded to a CT scan of facial bones, cervical spine, and head rather than plain films. CT of the neck and head were normal. CT of the facial bones showed that the patient had a mandibular fracture, nasal fracture, a tripod fracture of the left zygoma with orbital involvement, and an alveolar ridge fracture with a three-tooth fragment. A blowout fracture was confirmed on the CT scan.

Since the patient had altered sensorium from alcohol and/or head trauma and abundant facial trauma, you admitted him to the trauma service for observation and interval repair of the complex zygomaticomaxillary fracture. The ENT surgeon and the ophthalmologic surgeon are going to double team the patient for evaluation of the diplopia.

References

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study, will be included in bold type following the reference, where available. In addition, the most informative references cited in this paper, as determined by the authors, will be noted by an asterisk (*) next to the number of the reference.

1. Glynn SM, Shetty V, Elliot-Brown K, et al. Chronic post-traumatic stress disorder after facial injury: A 1-year prospective cohort study. *J Trauma.* 2007;62:410-418. **(Prospective study, 336 patients)**
2. Rusch MD, Grunert BK, Sanger JR, et al. Psychological adjustment in children after traumatic disfiguring injuries: A 12-month follow-up. *Plast Reconstructive Surg.* 2000;106:1451-1458. **(Prospective study, 57 patients)**
3. Tebble NJ, Adams R, Thomas DW, Price P. Anxiety and self-consciousness in patients with facial lacerations one week and six months later. *Brit J Oral Maxillofacial Surgery.* 2006;44:520-525. **(Prospective case series, 63 patients)**
4. Kelly P, Crawford M, Higuera S, Hollier LH. Two hundred ninety-four consecutive facial fractures in an urban trauma center: Lessons learned. *Plast Reconstructive Surg.* 2005;116:42e-49e. **(Retrospective case report, 198 patients with 294 fractures)**
5. Duma SM, Jernigan MV. The effects of airbags on orbital fracture patterns in frontal automobile crashes. *Ophth Plast Reconst Surg.* 2003;19(2):107-111. **(Retrospective database mining)**

*6. Alvi A, Doherty T, Lewen G. Facial fractures and concomitant injuries in trauma patients. *Laryngoscope.* 2003;113:102-106. **(Retrospective review, 151 patients)**

*7. Hogg N, Stewart TC, Girotti MJ. Epidemiology of maxillofacial injuries at trauma hospitals in Ontario, Canada between 1992 and 1997. *J Trauma.* 2000;49(3):425-432. **(Retrospective database mining)**

*8. Major MS, MacGregor A, Bumpous JM. Patterns of maxillofacial injuries as a function of automobile restraint use. *Laryngoscope.* 2000;110:608-611. **(Retrospective database review)**

9. Murphy RX, Birmingham KL, Okunski WJ, Wasser T. The influence of airbag and restraining devices on the patterns of facial trauma in motor vehicle collisions. *Plast Reconstructive Surg.* 2000;105:516-520. **(Retrospective review - database mining: Pennsylvanial Trauma Outcome Study)**
10. Bledsoe GH, Li G, Levy F. Injury risk in professional boxing. *Southern Med J.* 2005;98(10):994-998. **(Retrospective review)**
11. Francis DO, Kaufman R, Yueh B, et al. Air bag-induced orbital blow-out fractures. *Laryngoscope.* 2006;116:1966-1972. **(Case series of 150 orbital fractures derived from 2739 crashes in CIREN database)**

*12. Ferreira PC, Amarante JM, Silva PN, et al. Retrospective study of 1251 maxillofacial fractures in children and adolescents. *Plast Reconstructive Surg.* 2005;115:1500-1508. **(Retrospective study of 1251 fractures in 912 patients)**

13. van As AB, van Loghem AJ, Biermans BFJ, et al. Causes and distribution of facial fractures in a group of South African children and the value of computed tomography in their assessment. *Int J Oral Maxillofac Surg.* 2006;35:903-906. **(Retrospective case report, 107 patients)**
14. Bartkiw TP, Pynn BR, Brown DH. Diagnosis and managment of nasal fractures. *Int J Trauma Nurs.* 1995;1:11-18. **(Review article)**
15. Mondin V, Rinaldo A, Ferlito A. Management of nasal bone fractures. *Am J Otolaryngol.* 2005;26(3):181-185. **(Review article)**
16. Cox AJI. Nasal fractures - The details. *Facial Plastic Surg.* 2000;16:87-94. **(Review article)**
17. Kucik CJ, Clenney T, Phelan J. Management of acute nasal fractures. *Am Fam Physician.* 2004;70:1315-1320. **(Review article)**
18. Warwar RE, Bullock JD, Ballal DR, Ballal RD. Mechanisms of orbital floor fractures: A clinical, experimental, and theoretical study. *Ophth Plast Reconst Surg.* 2000;16(3):188-200. **(Cadaver and computer modelling study)**
19. Cruz AAV, Eichenberger GCD. Epidemiology and management of orbital fractures. *Curr Opin Ophthalmol.* 2004;15:416-421. **(Review Article)**
20. Harris GJ, Garcia GH, Logani SC, Murphy ML. Correlation of preoperative computed tomography and postoperative ocular motility in orbital blowout fractures. *Ophth Plast Reconst Surg.* 2000;16(3):179-187. **(Retrospective cohort study)**

*21. Jank S, Schuchter B, Emshoff R, et al. Clinical signs of orbital wall fractures as a function of anatomic location. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2003;96:149-153. **(Retrospective study of 424 patients)**

22. Kreidl KO, Dennis YK, Mansour SE. Prevalence of significant intraocular sequelae in blunt orbital trauma. *Am J Emerg Med.* 2003;21:525-528. **(Retrospective review)**
23. Soll SM. Trapdoor orbital fractures. *Ophth Plast Reconst Surg.* 2000;16(4):306-307. **(Letter)**
24. Tse R, Allen L, Damir M. The white-eyed medial blowout fracture. *Plast Reconstructive Surg.* 2007;119:277-286. **(Retrospective review, 5 cases)**
25. Burnstein M. Clinical recommendations for repair of orbital facial fractures. *Curr Opin Ophthalmol.* 2003;2003(14). **(Review)**
26. Fulcher TP, Sullivan TJ. Orbital roof fractures. *Ophth Plast Reconst Surg.* 2003;19(5):359-363. **(Retrospective case review, 21 patients)**

27. Azevedo AB, Trent RB, Ellis A. Population-based analysis of 10,766 hospitalizations for mandibular fractures in California, 1991-1993. *J Trauma.* 1998;45(6):1084-1087. **(Retrospective datamining study)**
28. Stacey DH, Doyle JF, Mount DL, et al. Management of mandible fractures. *Plast Reconstructive Surg.* 2006;117:48e-60e. **(Review article)**
29. Smartt JM, Low DW, Bartlett SP. The pediatric mandible: II. Management of traumatic injury or fracture. *Plast Reconstructive Surg.* 2005;116(2):28e-41e. **(Review article)**
30. Das UM, Nagarathna C, Viswanath D, et al. Management of facial trauma in children: A case report. *J Indian Soc Pedod Prev Dent.* 2006;Sept:161-163. **(Case report)**
31. Schlievert R. Infant Mandibular fractures: Are you considering child abuse? *Ped Emerg Care.* 2006;22(3):181-183. **(Case report)**
32. Biller JA, Pletcher SD, Goldberg AN, Murr AH. Complications and the time to repair of mandible fractures. *Laryngoscope.* 2005;115:769-772. **(Retrospective review 84 patients)**
*33. Boole JR, Holtel M, Amoroso P, Yore M. 5196 Mandible fractures among 4381 active duty army soldiers, 1980-1998. *Laryngoscope.* 2001;111(1691-1696). **(Retrospective review of 5196 fractures)**
34. Abubaker AO, Rollert MK. Postoperative antibiotic prophylaxis in mandibular fractures: A preliminary randomized, double-blind, and placebo-controlled clinical study. *Journal of Oral & Maxillofacial Surgery.* 2001;59(12):1415-1419. **(Prospective double blinded study)**
35. Furr AM, Schweinfurth JM, May WL. Factors associated with long-term complications after repair of mandibular fractures. *Laryngoscope.* 2006;116:427-430. **(Retrospective review of 64 patients)**
36. Whatley WS, Allison DW, Chandra RK, et al. Frontal sinus fractures in children. *Laryngoscope.* 2005;115:1741-1745. **(Retrospective review, 120 patients- 11 with frontal fractures)**
*37. Rice DH. Management of frontal sinus fractures. *Curr Opin Otolaryngol Head Neck Surg.* 2004;12:46-48. **(Review Article)**
38. Wallis A, Donald PJ. Frontal sinus fractures: a review of 72 cases. *Laryngoscope.* 1988;98(6 Pt 1):593-598. **(Retrospective review 72 patients)**
39. Hackl W, Fink C, Hausberger K, et al. The incidence of combined facial and cervical spine injuries. *J Trauma.* 2001;50:41-45. **(Retrospective review)**
40. Shimoyama T, Kaneko T, Horie N. Initial management of massive oral bleeding after midfacial fracture. *J Trauma.* 2003;54:332-336. **(Case report, 5 cases, literature review)**
41. Bynoe RP, Kerwin AJ, Parker HH, et al. Maxillofacial injuries and life-threatening hemorrhage: Treatment with transcatheter arterial embolizations. *J Trauma.* 2003;55:74-79. **(Retrospective review)**
42. Schultz RC. Soft tissue injuries of the face. In: Aston SJ, Beasley RW, Thorne C, eds. Plastic Surgery. *Philadelphia: Lippincott-Raven*, 1997:371-382. **(Reference text chapter)**
43. Meyers R, Haydel M, Robinson CS. Use of Physical Examination Findings to Identify Patients with Facial Fractures on Computed Tomography. 2005;12(5_suppl_1):14-b-15. **(Abstract-only presentation for SAEM)**
44. Schwab RA, Genners K, Robinson WA, et al. Clinical predictors of mandibular fractures. *American Journal of Emergency Medicine.* 1998;16(3):304-305. **(Convenience sample of 119 patients)**
*45. Alonso LL, Purcell TB. Accuracy of the tongue blade test in patients with suspected mandibular fracture. *Journal of Emergency Medicine.* 1995;13(3):297-304. **(Consecutive sample of 110 patients)**
46. Haydel, Meyers, Mills. Use of the Tongue-Blade Test to Identify Patients with Mandible & Maxillary Sinus Fractures. *Annals of Emergency Medicine* 2005;46(3):66-66. **(Abstract-only presentation at ACEP)**
47. Katzen JT, Jarrahy R, Eby JB, et al. Craniofacial and skull base trauma. *J Trauma.* 2003;54:1026-1034. **(Literature review)**
48. Barton FE, Berry WL. Evaluation of the acutely injured orbit. In: Aston SJ, Hornblass A, Meltzer MA, Rees TD, eds. Third International Symposium of Plastic and Reconstructive Surgery of the Eye and Adnexa. *Baltimore: Williams and Wilkins*, 1982:34. **(Reference text chapter)**
49. Weisman RA, Savino PJ. Management of patients with facial trauma and associated ocular/orbital injuries. *Otolaryngol Clin North Am.* 1991;24:37-57. **(Review article)**
50. Sharp JF, Denholm S. Routine x-rays in nasal trauma: The influence of audit on clinical practice. *J R Soc Med.* 1994;87:153-154. **(Editorial)**
51. Logan M, O'Driscoll K, Masterson J. The utility of nasal bone radiographs in nasal trauma. *Clin Radiol.* 1994;49:192-194. **(Prospective study, 100 patients)**
52. Nair MK, Nair UP. Imaging of mandibular trauma: ROC analysis. *Academic Emerg Med.* 2001;8(7):689-695. **(Cadaver study, 25 cadavers)**
*53. Chayra GA, Meador LR, Laskin DM. Comparison of panoramic and standard radiographs in the diagnosis of mandibular fractures. *J Oral Maillofac Surg.* 1986;44:677-679. **(Comparative study, 88 Fractures]**
*54. Moilanen A. Primary radiographic diagnosis of fractures in the mandible. *Int J Oral Surg.* 1982;11:299-303. **(Retrospective study, 272 fractures)**
55. Giovannini U, Goudot P. Radiological evaluation of mandibular and dentoalveolar fractures. *Plast Reconstructive Surg.* 2002;109(6):2165-2166. **(Letter)**
56. Hollier LH, Thornton J, Pazmino P, Stal S. The management of orbitozygomatic fractures. *Plast Reconstructive Surg.* 2003;111:2386-2393. **(Review article)**
57. Wilson IF, Lokeh A, Benjamin CI, et al. Prospective comparison of panoramic tomography (Zonography) and helical computed tomography in the diagnosis and operative management of mandibular fractures. *Plast Reconstructive Surg.* 2001;107:1369-1375. **(Prospective study, 73 mandibular fractures in 42 consecutive patients)**
58. Guss DA, Clark RF, Peitz T, Taub M. Pantomography vs. mandibular series for the detection of mandibular fractures. *Academic Emerg Med.* 2000;7(2):141-145. **(Prospective, blinded study of 54 patients)**
59. Staffel JG. Optimizing treatment of nasal fractures. *Laryngoscope.* 2002;112(10):1709-1719. **(Retrospective chart and literature review followed by a prospective, non-randomized sequential trial)**
60. Fernandes SV. Nasal fractures: the taming of the shrewd. *Laryngoscope.* 2004;114(3):587-592. **(Retrospective review)**
61. Li S, Papsin B, Brown DH. Value of nasal radiographs in nasal trauma management. *J Otolaryngol.* 1996;25:162-164. **(Questionnaire)**
62. Royal College of Radiologists Working Party. Making the best use of a department of clinical radiology: guideline for doctors (4th edition). Royal College of Radiologists. London, 1998. **(Policy Statement)**
63. Marlow TJ, Goltra DDJ, Schabel SI. Intracranial placement of a nasotracheal tube after facial fracture: a rare complication. *J Emerg Med.* 1997;15(2):187-191. **(Case report)**
64. Arrowsmith JE, Robertshaw HJ, Boyd JD. Nasotracheal intubation in the presence of frontobasal skull fracture. *Can J Anesth* 1998;45(1):71-75. **(Case report)**
65. Rosen CL, Wolfe RE, Chew SE, et al. Blind nasotracheal intubation in the presence of facial trauma. *J Emerg Med.* 1997;15(2):141-145. **(Retrospective study of 311 patients)**
66. Goodisson DW, Shaw GM, Snape L. Intracranial intubation in patients with maxillofacial injuries associated with base of skull fractures. *J Trauma.* 2001;50:363-366. **(Literature review)**
67. Schade K, Borzotta A, Michaels A. Intracranial malposition of nasopharyngeal airway. *J Trauma* 2000;49(5):967-968. **(Case report, review of literature)**
68. Caron G, Paquin R, Lessard MR, et al. Submental endotracheal intubation: An alternative to tracheotomy in patients with midfacial and panfacial fractures. *J Trauma.* 2000;48(2):235-240. **(Retrospective review 25 patients)**
69. Al-Qurainy IA, Stassen LF, Dutton GN, et al. The characteristics of midfacial fractures and the association with ocular injury: a prospective study. *British Journal of Oral and Maxillofacial Surgery.* 1991;29(5):291-301. **(Prospective study of 363 patients)**
70. Roth FS, Kokoska MS, Awwad E. et al. The identification of mandible fractures by helical computed tomography and panorex tomography. *J Cranial Facial Surgery.* 2005;16(3):394-399. **(Comparative study of physician interpretation)**
71. Lindstrom DR, Toohill RJ, Loehrl TA, Smith TL. Management of cerebrospinal fluid rhinorrhea: the Medical College of Wisconsin experience. *Laryngoscope.* 2004;114(6):969-974. **(Review article)**

CME Questions

1. **A trauma patient is reporting difficulty biting down. The most likely fracture involves the:**
   a. Malar eminence
   b. Zygomatic arch
   c. Mandible
   d. Vomer
   e. Glabella
2. **If the patient has cerebrospinal fluid drainage from the nose after facial trauma, you should:**
   a. Pack the area with gauze
   b. Increase the intravenous infusion rate
   c. Use a vasoconstrictive agent
   d. Consult the ophthalmologist
   e. Consult the neurosurgeon
3. **A patient with a blow-out orbital fracture typically has trouble looking in what direction?**
   a. Down
   b. Up
   c. Rightward gaze
   d. Leftward gaze
   e. Varies
4. **In a patient with midfacial fractures, you should not attempt to insert a (an):**
   a. Orogastric tube
   b. Nasogastric tube
   c. Oral airway
   d. Cricothyrotomy
   e. All of the above
5. **A major risk seen with severe facial fractures due to blunt trauma is:**
   a. Ocular injury
   b. Cervical spine injury
   c. Airway obstruction
   d. Intracranial head injury
   e. All of the above can be complications/associations of severe facial trauma
6. **A laterally directed injury to the nose is most likely to cause which of the following?**
   a. Cartilaginous disruption
   b. Limitation of ocular motion
   c. Telecanthus
   d. Fractures with posterior telescoping
   e. Contralateral displacement of the nose

7. **A 22-year-old ROTC drill team member presents after hitting his right cheek with his rifle butt during practice. He reports progressive difficulty with opening his mouth. Which of the following steps in evaluation is appropriate?**
   a. Treat the patient with nonsteroidal anti-inflammatory agents
   b. Have the patient apply cold compresses.
   c. Perform imaging studies and have the patient follow up with the oral surgeon if the zygomatic arch is fractured.
   d. Consult with the dentist
   e. Treat the patient with a muscle relaxant
8. **On examination of a patient with a severe facial fracture, you note that several teeth are missing. Your evaluation of this patient should include:**
   a. Cervical spine films
   b. Head/brain CT
   c. Chest X-ray
   d. All of the above should be obtained

Coming In Future Issues:

Jaundice

Narrow Complex Supraventricular Tachycardia

Class Of Evidence Definitions

Each action in the clinical pathways section of *Emergency Medicine Practice* receives a score based on the following definitions.

Class I
- Always acceptable, safe
- Definitely useful
- Proven in both efficacy and effectiveness

Level of Evidence:
- One or more large prospective studies are present (with rare exceptions)
- High-quality meta-analyses
- Study results consistently positive and compelling

Class II
- Safe, acceptable
- Probably useful

Level of Evidence:
- Generally higher levels of evidence
- Non-randomized or retrospective studies: historic, cohort, or case-control studies
- Less robust RCTs
- Results consistently positive

Class III
- May be acceptable
- Possibly useful
- Considered optional or alternative treatments

Level of Evidence:
- Generally lower or intermediate levels of evidence
- Case series, animal studies, consensus panels
- Occasionally positive results

Indeterminate
- Continuing area of research
- No recommendations until further research

Level of Evidence:
- Evidence not available
- Higher studies in progress
- Results inconsistent, contradictory
- Results not compelling

Significantly modified from: The Emergency Cardiovascular Care Committees of the American Heart Association and representatives from the resuscitation councils of ILCOR: How to Develop Evidence-Based Guidelines for Emergency Cardiac Care: Quality of Evidence and Classes of Recommendations; also: Anonymous. Guidelines for cardiopulmonary resuscitation and emergency cardiac care. Emergency Cardiac Care Committee and Subcommittees, American Heart Association. Part IX. Ensuring effectiveness of community-wide emergency cardiac care. *JAMA* 1992;268(16):2289-2295.

Physician CME Information

Date of Original Release: February 1, 2008. Date of most recent review: January 10, 2008. Termination date: February 1, 2011.

Accreditation: This activity has been planned and implemented in accordance with the Essentials and Standards of the Accreditation Council for Continuing Medical Education (ACCME) through the joint sponsorship of Mount Sinai School of Medicine and *Emergency Medicine Practice*. The Mount Sinai School of Medicine is accredited by the ACCME to provide continuing medical education for physicians.

Credit Designation: The Mount Sinai School of Medicine designates this educational activity for a maximum of 48 *AMA PRA Category 1 Credit(s)*™ per year. Physicians should only claim credit commensurate with the extent of their participation in the activity.

ACEP Accreditation: *Emergency Medicine Practice* is approved by the American College of Emergency Physicians for 48 hours of ACEP Category 1 credit per annual subscription.

AAFP Accreditation: *Emergency Medicine Practice* has been reviewed and is acceptable for up to 48 Prescribed credits per year by the American Academy of Family Physicians. AAFP Accreditation begins August 1, 2006. Term of approval is for two years from this date. Each issue is approved for 4 Prescribed credits. Credits may be claimed for two years from the date of this issue.

AOA Accreditation: *Emergency Medicine Practice* has been approved for 48 Category 2B credit hours per year by the American Osteopathic Association.

Needs Assessment: The need for this educational activity was determined by a survey of medical staff, including the editorial board of this publication; review of morbidity and mortality data from the CDC, AHA, NCHS, and ACEP; and evaluation of prior activities for emergency physicians.

Target Audience: This enduring material is designed for emergency medicine physicians, physician assistants, nurse practitioners, and residents.

Goals & Objectives: Upon completion of this article, you should be able to: (1) demonstrate medical decision-making based on the strongest clinical evidence; (2) cost-effectively diagnose and treat the most critical ED presentations; and (3) describe the most common medicolegal pitfalls for each topic covered.

Discussion of Investigational Information: As part of the newsletter, faculty may be presenting investigational information about pharmaceutical products that is outside Food and Drug Administration approved labeling. Information presented as part of this activity is intended solely as continuing medical education and is not intended to promote off-label use of any pharmaceutical product. Disclosure of Off-Label Usage: This issue of *Emergency Medicine Practice* discusses no off-label use of any pharmaceutical product.

Faculty Disclosure: It is the policy of Mount Sinai School of Medicine to ensure objectivity, balance, independence, transparency, and scientific rigor in all CME-sponsored educational activities. All faculty participating in the planning or implementation of a sponsored activity are expected to disclose to the audience any relevant financial relationships and to assist in resolving any conflict of interest that may arise from the relationship. Presenters must also make a meaningful disclosure to the audience of their discussions of unlabeled or unapproved drugs or devices.

In compliance with all ACCME Essentials, Standards, and Guidelines, all faculty for this CME activity were asked to complete a full disclosure statement. The information received is as follows: Dr. Stewart, Dr. Fiechtl, and Dr. Wolf report no significant financial interest or other relationship with the manufacturer(s) of any commercial product(s) discussed in this educational presentation.

Method of Participation:

- **Print Subscription Semester Program:** Paid subscribers with current and valid licenses in the United States who read all CME articles during each *Emergency Medicine Practice* six-month testing period, complete the post-test and the CME Evaluation Form distributed with the June and December issues, and return it according to the published instructions are eligible for up to 4 hours of CME credit for each issue. You must complete both the post test and CME Evaluation Form to receive credit. Results will be kept confidential. CME certificates will be delivered to each participant scoring higher than 70%.
- **Online Single-Issue Program:** Current, paid subscribers with current and valid licenses in the United States who read this *Emergency Medicine Practice* CME article and complete the online post-test and CME Evaluation Form at EBMedicine.net are eligible for up to 4 hours of Category 1 credit toward the AMA Physician's Recognition Award (PRA). You must complete both the post-test and CME Evaluation Form to receive credit. Results will be kept confidential. CME certificates may be printed directly from the Web site to each participant scoring higher than 70%.

Hardware/Software Requirements: You will need a Macintosh or PC to access the online archived articles and CME testing. Adobe Reader is required to view the PDFs of the archived articles. Adobe Reader is available as a free download at www.adobe.com.

Emergency Medicine Practice is not affiliated with any pharmaceutical firm or medical device manufacturer.

CEO: Robert Williford **President and Publisher:** Stephanie Williford **Director of Member Services:** Liz Alvarez

Direct all editorial or subscription-related questions to EB Medicine: **1-800-249-5770** • Fax: 1-770-500-1316 • Non-U.S. subscribers, call: 1-678-366-7933
5550 Triangle Parkway, Suite 150 • Norcross, GA 30092
E-mail: **ebm@ebmedicine.net** • Web Site: **EBMedicine.net**

Emergency Medicine Practice (ISSN Print: 1524-1971, ISSN Online: 1559-3908) is published monthly (12 times per year) by EB Practice, LLC, 5550 Triangle Parkway, Suite 150, Norcross, GA 30092. Opinions expressed are not necessarily those of this publication. Mention of products or services does not constitute endorsement. This publication is intended as a general guide and is intended to supplement, rather than substitute, professional judgment. It covers a highly technical and complex subject and should not be used for making specific medical decisions. The materials contained herein are not intended to establish policy, procedure, or standard of care. Emergency Medicine Practice is a trademark of EB Practice, LLC. Individual subscription price: $299, Institutional subscription price: $899 U.S. funds. (Call for international shipping prices.)