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Maxillofacial Trauma: Managing Potentially Dangerous And Disfiguring Complex Injuries

Abstract

Patients with maxillofacial trauma require a careful evaluation due to the anatomical proximity of the maxillofacial region to the head and neck. Facial injuries can range from soft-tissue lacerations and nondisplaced nasal fractures to severe, complex fractures, eye injuries, and possible brain injury. Though the Advanced Trauma Life Support (ATLS) guidelines provide a framework for the management of trauma patients, they do not provide a detailed reference for many subtle or complex facial injuries. This issue adds a more comprehensive and systematic approach to the secondary survey of the maxillofacial area and emergency department management of injuries to the face. In addition to an overall review of maxillofacial trauma pathophysiology, associated injuries, and physical examination, this review will also discuss relevant imaging, treatment, and disposition plans.

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Case Presentations

It is Saturday night and your third straight overnight shift. As you step into the trauma bay, your charge nurse approaches. "Doctor, we have a 27-year-old male coming in 5 minutes. He was involved in a high-speed motorcycle accident and EMS says he has quite a bit of facial trauma…" He trails off as you see EMS speeding down the hallway. Your resident looks at you and asks, "How are we going to intubate this patient?"

Your second patient arrives soon after. This patient is clearly inebriated and accompanied by both EMS and security. As the patient is brought closer, you note that he is combative and appears to have extensive facial injuries, with bleeding that you cannot identify as originating from any one location. The patient suddenly becomes minimally responsive, and the EMT repeats the vital signs, revealing a blood pressure of 60/40 mm Hg, heart rate in the 120s, and pulse ox, 88% on room air. You turn to your resident and ask, "What are our initial priorities in management of this patient?"

You are now exhausted and ready for your third cup of coffee when you decide to see your next patient, who was brought in by her friend. The friend states that the patient had been involved in an altercation with another patron at a bar earlier in the night. She was punched in the face several times and has had progressive swelling over the succeeding hours; now her lower face is deformed and she cannot clench her teeth. You wonder if you should begin with plain films of the jaw, a panoramic x-ray, or if you should go straight to CT...

Introduction

Over the past decades, the incidence of maxillofacial trauma has increased worldwide, due to increasing urbanization and industrialization. The etiology of facial injuries varies among different countries, depending on the socioeconomic, cultural, and environmental factors specific to the area.[1]

Maxillofacial injuries can be particularly difficult to evaluate, as they can range from simple soft-tissue lacerations to complex facial bone fractures.[1] Failure to recognize and adequately address concomitant injuries in a patient suffering multiple trauma may negatively impact overall morbidity. In one study, 9% of patients with significant maxillofacial trauma had coexisting brain injury.[2]

The primary goal in managing maxillofacial trauma in the emergency department (ED) is recognizing potential complications and managing a difficult airway, if the need arises. It is also fundamental to perform a full secondary survey that includes evaluating for possible nasal bone, orbital, maxillary, and mandibular fracture patterns. Initial assessment of a patient with maxillofacial injuries should also exclude any potential vision-threatening injury. Life-threatening blood loss from isolated maxillofacial injuries is uncommon; however, hypovolemia may result from concomitant injuries. Early assessment of all trauma patients requires consideration of potential cervical spine injuries, particularly in the unconscious or obtunded patient.

This issue of *Emergency Medicine Practice* provides a systematic review of the literature and makes best-practice recommendations to aid emergency clinicians in the initial management of patients who present with maxillofacial injuries. Currently, the Advanced Trauma Life Support (ATLS) guidelines are considered the gold standard for initial management of all trauma patients; however, many studies have addressed the shortfall of these guidelines.[3] This issue will supplement the ATLS guidelines by providing a more comprehensive discussion of diagnostic and management options for these patients.

Critical Appraisal Of The Literature

A literature search was performed using PubMed and MEDLINE®, with the search terms *maxillofacial trauma, craniofacial trauma, mandibular fracture, maxillary fracture, zygoma fracture, cervical spine injury, nasal fracture,* and *orbital fracture*. The reference section of each article was also reviewed for additional articles. Although the literature on maxillofacial injuries is extensive, most of the articles obtained were retrospective, case studies, or review articles. There are currently few prospective studies on maxillofacial injuries in the ED setting.

There are currently no national practice guidelines for patients presenting with maxillofacial injuries. Additionally, there are no Cochrane studies that directly address maxillofacial injuries. A study by Doerr rationalizes the scarcity of randomized controlled trials in maxillofacial trauma as being due to high costs, ethical constraints, subject recruitment, and variability of facial fractures.[4]

Epidemiology And Etiology

Maxillofacial trauma is often associated with morbidity and high financial cost.[5] In 2007, a Nationwide Emergency Department Sample (NEDS) study found that, in the United States, 407,167 ED visits were for facial injury.[6] The average age of patients was 38 years, and 68% were male. The most frequently reported causes of injuries included assaults (37%), falls (27%), and motor vehicle crashes (12%). The mean charge per ED visit was $3192, with a total financial burden of ED visits for facial trauma close to $1 billion. International studies of the incidence, sex and age distribution, and etiology of maxillofacial injuries show very similar results.[7] The major distinguishing factors among other nations' incidence of facial injuries is largely dependent on the industrialization and socioeconomic factors specific to each nation.[1,8-12]

A complete history can contribute to understanding the circumstances related to maxillofacial trauma.

A 2-year audit of emergency referrals for maxillofacial trauma at a single hospital site in the United Kingdom revealed a 72% association between alcohol consumption and interpersonal violence.[13]

In a 10-year study involving 3385 pediatric patients younger than 15 years, Gassner et al found that the incidence of pediatric facial fractures varied, depending on age, with estimates ranging from 1% to 15% for children aged < 16 years and 1% for children aged < 5 years.[14] The majority of injuries sustained by children are related to dentoalveolar structures and soft-tissue injuries. However, this may vary, depending on the age of the child and the degree of underdevelopment of the facial bones and dentition.[14,15] In a 15-year review of 174 pediatric patients aged < 16 years, Iida et al reported that the male-to-female ratio of pediatric maxillofacial injury is 2:1, with the largest age group sustaining injury being aged < 15 years. The most common causes of injury were bicycle accidents and falls; however, assaults were an increasing cause of injury as children approached adolescence.[16]

The incidence of concomitant injuries is relatively high and increases further, depending on the high-impact nature of the trauma. In one study by Deliverska et al, the injuries most frequently associated with maxillofacial injures included closed-head trauma with loss of consciousness (63%), extremity injury (22%), ophthalmologic injuries (18%), traumatic brain injuries (13%), cervical spine injuries (5%), and abdominal injuries (1%).[17]

Pathophysiology

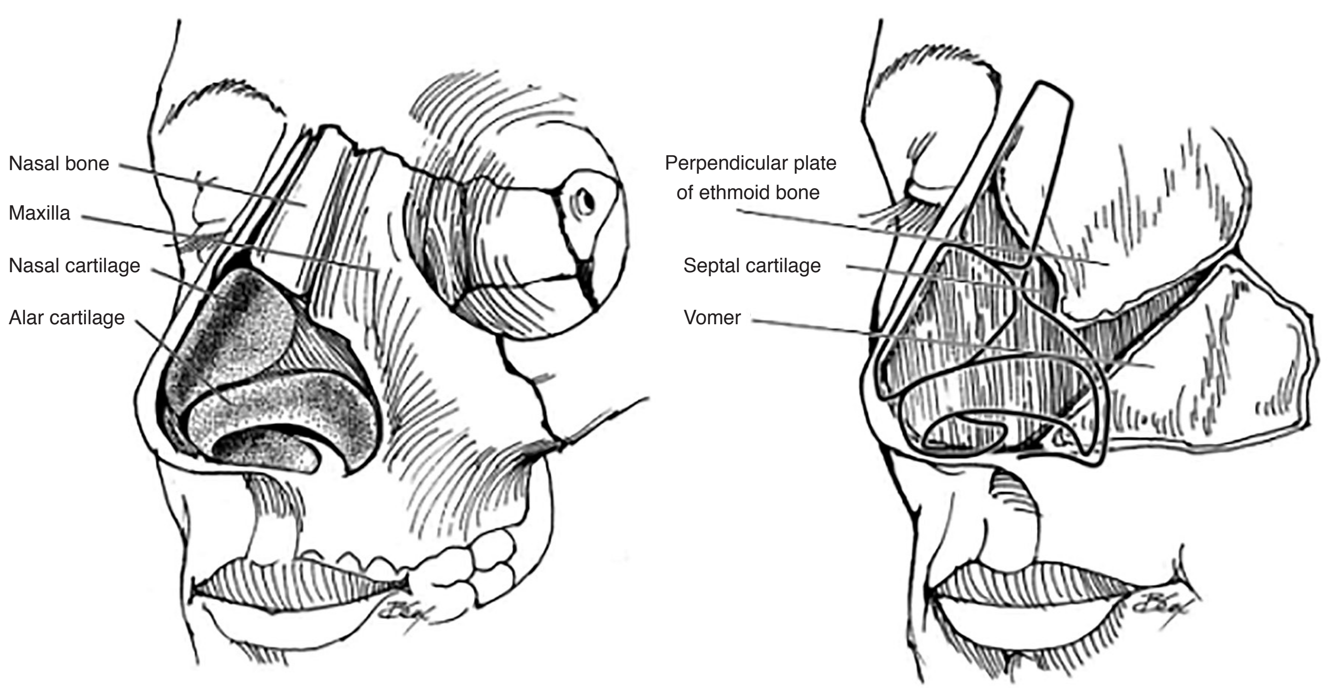
Nasal Bone Fractures

Nasal bone fractures account for approximately 40% of bony injuries in facial trauma. Assault and sports injuries cause the majority of nasal fractures, followed by falls and motor vehicle crashes. The potential for physical abuse should always be explored. Nasal fractures may occur in isolation, but other associated facial or mandibular fractures may also present.[18,19]

The nose is easily exposed to trauma, as it is the most anterior and prominent feature of the face. It is supported primarily by cartilage, anteriorly and inferiorly, and by bone, posteriorly and superiorly. A network of paired nasal bones, the nasal process of the frontal bone, and the maxilla largely support the nasal cartilage. **(See Figure 1.)** In addition to cartilage and bone, the soft tissue, mucus glands, muscles, and nerves are responsible for the sensation and function of the nose, and are also at risk for injury.[20] Epistaxis can occur with even minor trauma, as a result of a dense and redundant vascular network, known as the Kiesselbach plexus. However, bleeding secondary to nasal fractures results largely from other areas within the nose. Injury to the anterior ethmoid artery (a branch of the ophthalmic artery) may cause profuse anterior nasal bleeding. Alternatively, injury to a branch of the sphenopalatine artery may cause posterior nasal bleeding.

Of particular importance in any patient present-

Figure 1. Nasal Bone Anatomy



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ing with nasal trauma is full assessment for septal hematomas, as they can lead to permanent deformity if untreated. Septal hematomas appear as slightly fluctuant white or purple areas on one or both sides of the nasal septum.

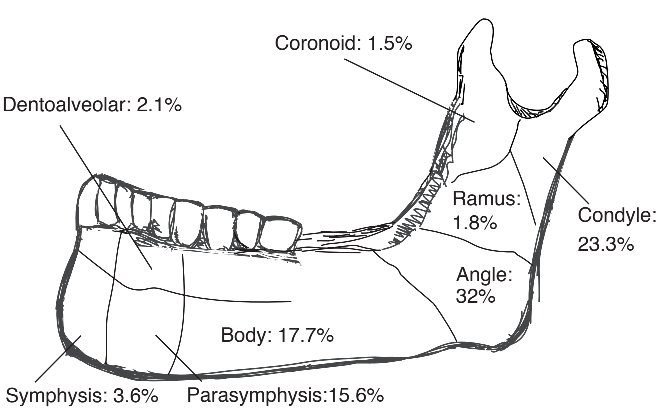
Mandibular Fractures

Mandibular fractures are common following motor vehicle crashes, interpersonal violence, and sport-related injuries.[9] Care must be taken with mandibular fractures, as they may hinder swallowing.[21]

The mandible is a mobile, U-shaped bone composed of thick buccal and lingual cortices within a thin medullary canal. The mandible is composed of paired condyle, coronoid, ramus, angle, body, and midline symphyses. **Figure 2** notes these cortices, along with the percentage of frequency of occurrence of fractures in each area. The anterior coronoid and posterior condyle compose the superior aspect of the mandible, which then articulates with the glenoid fossa to form the temporomandibular joint. The neurovascular supply to the mandible consists of the inferior alveolar nerve and artery. The mental nerve exits the mental foramen below the second bicuspid and provides sensation to the skin and mucosa of the lower lip. Two main muscle groups control the mandible. When a mandibular fracture exists, these muscles work in opposition.[22]

Generally, mandibular fractures are classified based on the anatomic location involved at the fracture site. These sites include the symphysis, body, angle, ramus, condylar process, coronoid process, and alveolar process. A full history of the mode and mechanism of injury, in addition to the magnitude and direction of force involved, may help in predicting the type of injury.[23] For example, an anterior impact sustained in a motor vehicle crash will likely result in symphyseal, parasymphyseal, and condylar fractures. Alternatively, a lateral impact will result in an angle and body fracture.

Figure 2. Mandibular Bone Structure, With Location And Frequency Of Area Fractures



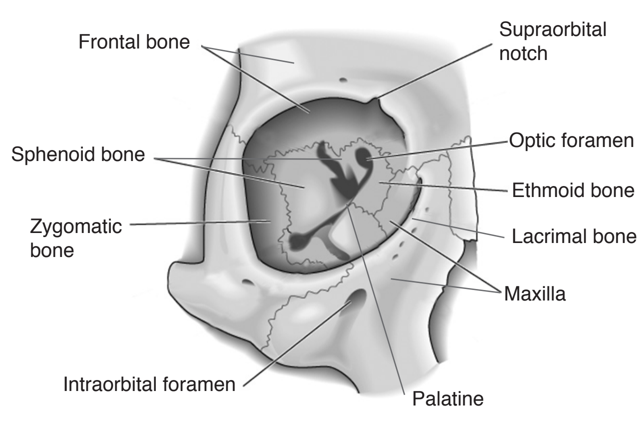
Orbital Fractures

Orbital fractures commonly occur in males in the third decade of life. In one study of 200 patients by Septa et al, orbital injuries were present in 169 cases (84.5%) and included subconjunctival hemorrhages, corneal injuries, diplopia, and enophthalmos.[5] In adults, orbital fractures are typically the result of motor vehicle crashes or interpersonal violence, whereas in pediatric patients, orbital fractures most often occur due to falls or sports-related injuries. Orbital fractures are often broadly categorized as "blowout" fractures; however, orbital fractures typically do not occur in isolation. For example, Le Fort II and III fractures, zygomaticomaxillary fractures, and naso-orbito-ethmoid complex fractures also involve orbital fractures.[5,24,25]

The orbit is composed of 7 facial bones: frontal, zygoma, maxilla, lacrimal, ethmoid, sphenoid, and palatine. **(See Figure 3.)** The optic nerve exits the optic foramen through the sphenoid bone. The globe of the eye sits within the orbit and is surrounded by periorbital fat and extraocular muscles. The inferior orbital nerve courses through the orbital floor in the maxilla. The weakest portions of the orbit, and therefore the most frequently fractured, are the thin orbital floor bones, the maxilla and the lamina papyracea (ethmoid bone), medially and anteriorly.

Blowout fractures occur as a result of a direct blow to the eye that causes increased orbital pressure and subsequent fracturing of the weak lamina papyracea (floor) into the maxillary sinus or ethmoid bone. Though this mechanism commonly causes a fracture, it often prevents globe rupture by decreasing intraorbital pressure. Some studies report the occurrence of ocular injuries in facial trauma to be as high as 40%.[26-28] Examples of such injuries include ruptured globe, retro-orbital hemorrhage, vitreous hemorrhage, hyphema, dislocated lens, secondary

Figure 3. Orbital Bones Of Right Eye



Paul Riordan-Eva, Emmett T. Cunningham, Jr., eds. *Vaughan & Asbury's General Ophthalmology*, 18th edition. Copyright 2011, McGraw-Hill Education. Used with permission.

glaucoma, choroidal rupture, and retinal tear or detachment. Of concern is the potential for periorbital fat and extraocular muscles becoming trapped within the fracture segments.

Zygomatic Fractures

Zygomatic fractures are typically sustained in motor vehicle crashes[29] and occur mostly in men in their second and third decades of life. The zygoma is largely responsible for maintaining the normal facial width and prominence of the cheek. The zygoma articulates with 3 bones: medially by the maxilla, superiorly by the frontal bone, and posteriorly by the greater wing of the sphenoid bone within the orbit. Anteriorly attached to the zygoma are the zygomaticus minor and major muscles and the orbicularis oculi muscle. Laterally, the masseter muscle attaches to the zygomatic arch. Four parts, or processes, comprise the zygoma and include the maxillary, temporal, frontal, and orbital processes.

Due to the thickness of the bone, isolated zygomatic fractures are uncommon. However, it is possible to sustain a zygomatic arch fracture, usually secondary to a blow to the side of the face. A complication associated with zygomatic arch fractures includes impingement of the temporalis muscle, causing trismus. The most common fracture is the tripod or zygomaticomaxillary complex fracture that involves separation of all 3 major attachments of the zygoma from the rest of the face. This is usually the result of a direct blow to the body of the zygoma. The complication associated with such an injury is entrapment of the extraocular muscles in the zygomaticomaxillary component of the fracture complex. The displaced tripod fragment may physically restrict motion of the mandible. Occasionally, there may be a propagation of the forces along the lateral orbital wall involving the optic canal, resulting in decreased vision. A third type of fracture is an alveolar process fracture of the maxilla. This type of fracture includes a small piece of the maxilla and several fractured teeth.[30]

Maxillary Fractures / Le Fort Fractures

The maxilla makes up a large part of the facial bone structure and consists of the bridge between the cranial bone superiorly and the dental occlusion plane inferiorly. Maxillary fractures account for approximately 6% to 25% of all facial fractures.[23] These fractures are often the result of high-energy blunt force injuries such as those sustained from motor vehicle crashes, physical altercations, and falls. Because of the maxilla's association with the oral cavity, nasal cavity, and orbits, injury to the maxilla may be life-threatening as well as cosmetically disfiguring.

Fractures involving separation of the maxilla from the skull bone are commonly described according to the classification system derived by Rene Le Fort in 1901. Le Fort classifications describe fractures that are sustained in a predictable pattern after blunt force is applied and separation of all or part of the maxilla from the skull base occurs.[31] **(See Figure 4.)**

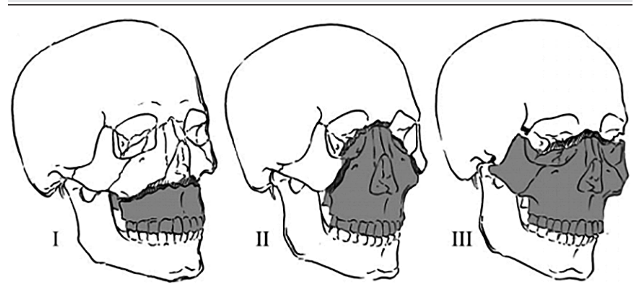
- Le Fort I fractures, or horizontal fractures, may result from a downward force directed toward the maxillary alveolar rim. The fracture extends from the nasal septum to the lateral pyriform rims, travels horizontally above the teeth apices and crosses the zygomaticomaxillary junction. Patients may present with an anterior open bite, mobile maxillary dental arch, or step deformity intraorally.[32]
- Le Fort II fractures, or pyramidal fractures, may result from a direct blow to the lower or mid maxilla. This fracture forms a pyramidal shape and extends from the nasal bridge through the frontal processes of the maxilla, inferolaterally through the lacrimal bones and inferior orbital floor, and then travels under the zygoma.
- Le Fort III fractures, or transverse fractures, may result from impact to the nasal bridge or upper maxilla. These fractures start at the nasofrontal and frontomaxillary sutures and extend posteriorly along the medial wall of the orbit through the nasolacrimal groove and into the ethmoid bones. Only Le Fort III fractures involve the lateral orbital wall and zygomatic arch; therefore, cerebrospinal fluid (CSF) leakage may occur.[32]

The Le Fort classification may be an oversimplification of the extent of maxillary fractures sustained after blunt trauma. Most fractures are a combination of various Le Fort fractures. In very high-energy trauma, maxillary fractures may occur in combination with fractures to the mandible, cranium, or both.[31]

Frontal Sinus Fractures

The frontal sinus is protected by a thick cortical bone and is typically more resistant to fracture than other

Figure 4. Le Fort Fracture Patterns



Richard A. Hopper, Shahram Salemy, Raymond W. Sze. Diagnosis of Midface Fractures with CT: What the Surgeon Needs to Know. *RadioGraphics.* Volume 26, Issue 3. With permission of the Radiological Society of North America.
DOI: http://dx.doi.org/10.1148/rg.263045710

facial bones. The frontal sinus is absent at birth, becomes radiographically identifiable at age 8, and matures to full size at age 15. Frontal sinus fractures occur only with high-impact traumas such as motor vehicle crashes, assaults, industrial accidents, and sports injuries. In a retrospective 28-year review of over 200 patients, frontal sinus fractures rarely occurred in isolation and were often associated with intracranial injuries.[33]

The frontal sinus is composed of the anterior table, posterior table, and frontal recess. The anterior table is 2 mm to 12 mm thick and requires approximately 800 to 1600 foot-pounds of pressure for a fracture to occur. Alternatively, the posterior table is 0.1 mm to 4.8 mm thick and offers little protection to intracranial injuries. Isolated posterior table fractures are rare, whereas one-third of frontal sinus fractures are limited to the anterior table.[33] In a study of 202 consecutive patients presenting with frontal sinus fractures, anterior and posterior table fractures were the most common fractures sustained, and isolated frontal recess fractures were the most rare.[33] Long-term sequelae of frontal sinus fractures include chronic sinusitis, mucocele, mucopyocele, meningitis, brain abscess, frontal osteomyelitis, and CSF leak.[34]

Differential Diagnosis

Maxillofacial trauma rarely occurs in isolation. A patient presenting with facial trauma requires systematic and repeated assessment with a multidisciplinary trauma team. Other injuries to be concerned about in patients presenting with maxillofacial injuries include:

- Facial injuries resulting in airway compromise
- Anterior neck injuries resulting in airway compromise, including laryngeal or tracheal injuries
- Injuries resulting in profound blood loss
- Cervical spine or brain injuries
- Vision-threatening injuries[35]

Prehospital Care

Literature regarding prehospital care of patients with maxillofacial trauma consists mostly of case reports and review articles. Prehospital personnel must ensure that the airway, breathing, and circulation needs of the patient are addressed. In addition, all patients with significant maxillofacial trauma should be placed in cervical spine precautions, particularly if the patient is obtunded. The risk of aspiration and loss of airway must be balanced against the need to immobilize the cervical spine. Epistaxis should be controlled with direct pressure. Because swallowed blood often results in emesis, suction and an emesis basin should be kept ready.

Emergency Department Evaluation

Initial Stabilization And Key Historical Questions

The "ABCDE" approach of the ATLS guidelines is designed to recognize and simultaneously manage life-threatening problems in the order that may be potentially lethal. **Table 1** includes key historical questions that should be asked of any patient suffering from maxillofacial injuries.

1. Is the airway intact?

The main cause of death in severe facial injury is airway obstruction. In the awake, immobilized patient, observing the airway may facilitate clinical assessment, but at the risk of possible further bleeding, vomiting, or sudden decompensation.[3] An agitated patient may be hypoxic, an obtunded patient may be hypercarbic, and a cyanotic patient may be hypoxemic secondary to inadequate oxygenation.[23] Soft-tissue swelling and edema (for example, a retropharyngeal hematoma) may complicate the clinical course. Maxillofacial trauma may be associated with swelling around the upper airway as a result of trauma around the oral cavity or the larynx and trachea. This may cause obstruction of the airway by swelling or displacement of structures such as the epiglottis, arytenoid cartilage, and vocal cords. A high index of suspicion should be maintained, and any neck swelling, dyspnea, voice changes, or crepitus along the neck should be noted.[36]

Prior to establishing a definitive airway, any foreign bodies within the oral cavity must be removed by either suctioning or physical removal with Magill forceps. A simple jaw thrust or chin-lift maneuver may be used to alleviate any soft-tissue obstruction caused by the tongue, anterior neck tissue, or epiglottis, but this may be difficult to perform in patients with severe comminuted mandibular fractures.[37] If the patient is still unable to protect his or her airway, it may be necessary to perform endotracheal intubation. In some patients, endotracheal intubation may not be possible, and cricothyroidotomy or tracheostomy may be necessary.

Table 1. Key Patient Historical Questions

- Did you have any loss of consciousness?
- Are you currently on any medications, have past medical history, or allergies?
- What were the events leading to the injury?
- Do you have any vision problems, such as double or blurred vision?
- Do you have any pain with eye movement?
- Do you have any hearing problems?
- Does it feel like your jaw is not properly in line? Are you able to bite down without pain?
- Are there areas of numbness or tingling around the face?
- Is there any epistaxis or clear fluid coming from the nose or ears?

2. Is the patient ventilating adequately?
A large percentage of patients who present with maxillofacial trauma will also have severe concomitant injuries. One example is the patient who presents with fluctuating levels of consciousness. An intoxicated, combative patient may initially appear to have an intact airway, but then quickly decompensate or start ventilating inadequately. These patients may present with full stomachs, and may vomit, causing the patient to aspirate and become obtunded.[37]

3. Is the patient's circulation being addressed adequately?
Life-threatening blood loss from maxillofacial injuries is uncommon, but blood loss from the scalp, face, and neck can sometimes be profuse. Blood loss from occipital scalp lacerations can be overlooked in the supine patient and must be diligently searched for and stopped. Midface bleeding can be difficult to control, given the extensive collateral blood supply derived bilaterally from the internal and external carotid arteries. Of note, even relatively "minor" facial injuries, such as nasal fractures and displaced mandibular fractures, may cause continued slow bleeding that may lead to the eventual need for aggressive resuscitation.[38]

Rapid closure of actively bleeding wounds (such as on the scalp) may be accomplished by stapling or continuous suturing. If bleeding is present from a deeper source (such as a puncture wound), placing the tip of a urinary catheter into the wound and inflating the balloon may be a temporary solution. However, care must be taken to ensure that there is no damage to adjacent deep structures. Immediate temporary reduction of fractures may be necessary to stop and control bleeding. Ligation of the external carotid artery may be helpful if bleeding continues; however, given the complexity of facial vascular anatomy, it may be more prudent for patients to undergo angiography and selective embolization under specialized consultant care. Even then, there is a high risk of embolic material crossing into the brain and causing irreversible neurologic complications.[39]

If initial measures to control bleeding are unsuccessful, consider whether the patient may have other reasons for coagulation abnormalities (eg, hemophilia or antiplatelet or anticoagulant therapy). In such situations, it may be necessary to activate a massive transfusion protocol. This may involve obtaining multiple blood products as well as reversal agents.

4. Has the patient's neurologic status been assessed fully?
Patients presenting with severe maxillofacial trauma often have distracting injuries that prevent a timely clearance of the cervical spine. In addition, particular care must be taken with patients who are obtunded or unconscious.[3,38] Previous studies have shown that the risk of concomitant cervical spine injuries is < 10% in all facial trauma patients. These studies also show a decreased risk of cervical spine injuries in younger patients, female patients, and in patients with facial soft-tissue lesions or dental trauma alone. However, Gassner et al reported that, in 9543 patients with maxillofacial injuries, 19.6% had sustained cerebral and cervical spine injuries.[9]

Key Physical Examination Components/ Findings

Once the primary survey is complete, the emergency clinician may move forward with a full secondary survey, which should include the following components:

1. Observe for facial asymmetry.
The emergency clinician who is located at the head of the bed will be at the most ideal location to assess for any facial asymmetry. This view allows observation for proptosis or other obvious signs of swelling.

2. Palpate the nares and nasal bridge for tenderness and crepitus. Inspect the nasal septum for clear rhinorrhea, indicating CSF leak, and for septal hematoma(s).
Typically, nasal fractures will present with swelling, tenderness, obvious deformity, crepitus, epistaxis, or ecchymosis. A complete examination of the nose includes palpation of the nasal structure to elicit any crepitus, malformation, or irregularity of the nasal bone. Soft-tissue injuries within the nose, including mucosal lacerations, may often bleed profusely and may need to be addressed immediately. It is also imperative to recognize septal hematomas in order to prevent future saddle-nose deformity.

In assessing for potential CSF leak, visualizing clear rhinorrhea, subcutaneous emphysema, mental status changes, new malocclusion, or limited extraocular movements should prompt immediate intervention. CSF rhinorrhea is particularly worrisome because it may indicate a cribriform plate disruption of the ethmoid bone, basal skull fracture, or temporal bone fracture.[40,41] The detection of CSF leakage is vitally important, as studies (such as that by Yellinik et al) have shown that a persistent CSF leak increased the risk for future meningitis.[42] CSF leak was observed most frequently in patients with fractures in the ethmoid, zygomatic, and/or maxillary bones. All cases with CSF leak had concomitant skull base fractures.[43]

3. Check facial stability by grasping the teeth and hard palate and gently pushing horizontally then vertically, feeling for movement or instability of the midface.
If any facial instability is detected, further inspection should be performed using the other hand to

palpate along the nasal bridge, infraorbital rims, and zygoma. In a Le Fort I fracture, there will be mobility limited to the hard palate and facial edema. In a Le Fort II fracture, there will be mobility of the zygoma in addition to marked facial edema and bilateral subconjunctival hemorrhages. Movement of the nasal bridge may also indicate a Le Fort II fracture. A Le Fort III fracture involves complete disruption of the facial bone structure and will present with facial flattening. Grasping the patient's teeth and hard palate will result in complete mobility of the entire face. These patients will almost inevitably sustain CSF leakage and epistaxis.

4. Palpate the mandible along its symphysis, body, angle, and coronoid process to check for tenderness, swelling, and step-off.
When assessing for mandibular fractures, palpation should be performed both intraorally and extraorally, feeling for crepitus and assessing for pain or tenderness of the mandible. The clinician should look for signs of pain, swelling, trismus, tenderness, step deformity, mobility, gingival tear, and decreased sensation in the lower lip.[23] The key to fully assessing a potential mandibular fracture is to assess for occlusion. Test the teeth for stability and inspect for bleeding at the gum line, which is a sign of fracture through the alveolar bone. The clinician should assess for the presence of a sublingual hematoma.

The tongue blade test is a screening test for a mandibular fracture. In this examination, the emergency clinician places a tongue blade inside the mouth on each side of the jaw and asks the patient to bite down. As the clinician twists the blade, if the patient is able to break the blade while biting down, studies have shown a 95.4% sensitivity in excluding a mandibular fracture. However, this test cannot stand alone as a rule-out diagnostic test.[44,45] Bleeding from the ear may also indicate the presence of a condylar fracture, due to a tear in the anterior wall of the meatus.[23]

5. Palpate the zygoma along its arch, as well as its articulations with the frontal bone, temporal bone, and maxilla.
Zygoma fractures typically present with periorbital ecchymosis, lateral subconjunctival hemorrhages, infraorbital decreased sensation, step-off of the orbital rim, and depression of the malar eminence. Remember that zygomatic arch fractures may present with trismus due to impingement of the temporalis muscle. A large majority of patients (70%-90%) who present with zygoma fractures complain of infraorbital/upper lip paresthesia.[30] The affected side of the face may appear flattened, although this is often very subtle. Occasionally, patients may present with epistaxis as a result of disruption of the membrane of the maxillary sinus or abnormal occlusion of the fracture, preventing normal mandibular movements.[30] Zygomatic arch fractures can be difficult to diagnose clinically, but will often present with a dimple that is palpable on the arch or with a decreased range of mouth opening.

6. Palpate bony structures of the supraorbital ridge and frontal bone for step-off fractures.
Frontal sinus fractures are uncommon, but when they occur, they are rarely in isolation and are often associated with intracranial injuries. Patients may present with loss of consciousness, be obtunded, or have visual complaints such as diplopia, blurred vision, or decreased acuity. Occasionally, patients may present with soft-tissue lacerations, palpable step-offs, or bony fragments.[33]

7. Evaluate the supraorbital, infraorbital, inferior alveolar, and mental nerve distributions for anesthesia.
Orbital fractures may present with a variety of symptoms including periorbital ecchymosis, diplopia, hypoesthesia in the V2 distribution, and intraorbital emphysema. Alternative diagnoses, such as orbital hemorrhage or edema (without blowout), bruised extraocular muscle, and cranial nerve palsy should be considered and systematically ruled out.[26] It is also important to examine eyelids for lacerations. The possibility of globe penetration should also be considered.

8. Perform a full visual examination.
This is important so that potential vision-threatening injuries are not missed. **(See Table 2.)** Depending on the cause of ocular trauma, a patient may be asymptomatic or may present with symptoms of orbit or globe involvement. Any patient who presents with blunt orbital trauma should be suspected of having a blowout fracture. The most common physical examination signs of orbital fractures include periorbital ecchymosis, diplopia, hypoesthesia in V2 distribution, and intraorbital emphysema. Alternative diagnoses, such as orbital hemorrhage or edema (without blowout), bruised extraocular muscle, and cranial nerve

Table 2. Components Of The Visual Examination

- Examine extraocular movements, especially in upward and lateral gaze (if possible).
- Check visual acuity (if possible).
- Check the cornea for abrasions or lacerations using fluorescein, if needed.
- Examine the anterior chamber for the presence of blood or hyphema (if possible).
- Perform a funduscopic examination to check for blood in the posterior chamber (if possible).
- Examine the retina for signs of detachment.
- Test for diplopia (if possible).

palsy should be considered and systematically ruled out.[26] A retrobulbar hemorrhage is a rare but vision-threatening complication of eye trauma that results in accumulation of blood in the retrobulbar space.[27] For more information on management of retrobulbar hemorrhage, see the November 2015 issue of *Emergency Medicine Practice,* "Ocular Injuries: New Strategies In Emergency Department Management" at www.ebmedicine.net/OcularTrauma.

9. If possible, perform a detailed cranial nerve examination.

Cranial nerve V (CN V) (trigeminal nerve) injuries are common in patients with severe maxillofacial injuries. The supraorbital and infraorbital nerves are injured in trauma to the forehead, orbit, and maxilla. The inferior dental branch and the mandibular division can be injured in fractures of the mandible. Skull-base injuries that involve the cavernous sinus region can result in ocular motor dysfunction with sensory impairment over the ophthalmic division. These patients should be checked for sensation along the cutaneous distribution of CN V. CN VII (facial nerve) injuries are also common, and present with decreased sensation and paralysis of the muscles of facial expression. **(See Table 3.)**

In an unconscious or obtunded patient, it is more difficult to perform a full cranial nerve examination. Pupillary reflexes can be assessed if the efferent pathway is intact. If significant periorbital swelling or bruising is present, ultrasound may be used to assess for consensual pupillary reflex by placing a linear transducer probe over the affected eye and shining a light into the unaffected eye. If CN III is intact, it will be possible to observe consensual pupillary constriction on ultrasound imaging of the affected eye. The swinging light test is used to check for the Marcus Gunn pupillary reflex, which indicates a unilateral afferent CN II injury.

Table 3. Abbreviated Cranial Nerve Examination

Cranial Nerve	Test
II (optic nerve)	Perform visual acuity test
III (oculomotor nerve)	Check extraocular movements
IV (trochlear nerve)	Check extraocular movements
V (trigeminal nerve)	Check for corneal reflex; check sensation to light touch, sharp touch, and hot and cold; check motor function by having patient open jaw and clench teeth
VII (facial nerve)	Check for decreased sensation and paralysis of the muscles of facial expression
VIII (vestibulocochlear nerve)	Check cold water caloric reflex test
IX (glossopharyngeal nerve)	Check gag reflex
X (vagus nerve)	Check gag reflex

In this examination, if a light is directed toward the normal eye, both pupils will constrict. When the light is swung toward the affected or damaged eye, both pupils will dilate. If a CN VII injury is present, there may be incomplete eye closure with Bell's phenomenon, and blowing in and out of the cheek with breathing. Additionally, bleeding from the ear, CSF otorrhea, Battle sign, and hearing impairment are other features consistent with possible facial nerve injury.[46]

10. Fully undress the patient to examine the entire body for other potential sources of injury.

A patient with distracting injuries may not be aware of other injuries, such as bite marks or puncture wounds.

Diagnostic Testing

Laboratory Testing

Cerebrospinal Fluid

The glucose oxidase test is used when a CSF leak is suspected, as the presence of glucose is considered suspicious for the presence of CSF; however, this is not recommended as a confirmatory test due to its poor sensitivity and specificity.[40] Another method used to detect CSF rhinorrhea or CSF otorrhea is the double-ring sign or halo sign. This test uses the principle of chromatography, which notes that different components of a fluid mixture will separate at different rates as they travel through a medium. However, the value of this sign has been debated, and an experiment conducted with blood and other fluid components showed that CSF will create a visible ring 30% to 90% of the time, as will blood mixed with saline and tears.[41] Other laboratory tests to identify CSF include beta-trace protein and beta-2 transferrin. Both are highly sensitive and specific for CSF, with beta-2 transferrin being the gold standard. The beta-2 transferrin test requires submission of suspected CSF to the laboratory for analysis for beta-2 transferrin, which is a CSF-specific variant of transferrin.[47] This is a more rigorous process than the methods described above, but it is more specific.

Imaging Studies

The increasing availability of high-resolution computed tomography (CT) has allowed for increased efficiency and obviates the need for obtaining initial plain radiographic films. However, it is still important to be familiar with plain radiographs of the maxillofacial area. This knowledge will aid the clinician when evaluating the maxillofacial CT. CT scans afford nearly simultaneous assessment of head and cervical spine injuries. Although magnetic resonance imaging (MRI) is another imaging option, it is not typically used in an emergency setting due to its limited availability and the extended duration of testing.

Facial Radiographs

Four common radiographic views are typically used to evaluate maxillofacial trauma. These include the Waters view, the Caldwell view, the lateral view, and the basal view. The Towne view is also a common plain film view used to evaluate facial fractures. **Table 4** describes the typical radiographic views.

The most helpful view in facial trauma is the Waters view, because it shows all of the major facial structures. **(See Figure 5.)** However, a review of the most relevant 5 studies suggests that, although a single view is sensitive in identifying facial fractures, adding an additional view prevents missing fractures of the midface.[48] **See Figure 6 and Figure 7** for the angles of the Waters and Caldwell views.

A systematic approach to interpretation of facial radiographs will minimize the chances of missing a maxillofacial fracture. Familiarity with the normal anatomy and the corresponding contours or lines will allow for recognition when an abnormal finding exists. Tracing smooth, uninterrupted, symmetric lines will ensure that the pertinent areas are evaluated completely. Examples of contours to know include the lines of Dolan in the Waters view and Campbell lines in the Caldwell view.[49]

Always assess the orbits in all of the available views obtained. Carefully assess the orbital walls, apex, and canal. The most common facial fracture patterns are the zygomaticomaxillary complex (tripod fracture); Le Fort I, II, and III fractures; zygomatic arch fractures; and orbital blowout fractures.

Direct signs of facial fractures include a nonanatomic linear lucency, the separation sign, the overlap sign, abnormal linear density, and the "disappearing"

Table 4. Typical Radiographic Views Used During Evaluation Of Facial Fractures

View	Alternative Terminology	Structures Visualized
Waters view	Occipitomental	Maxillary sinuses, frontal sinuses, zygomatic bones, zygomatic arches, inferior orbital floor
Caldwell view	Occipitofrontal	Frontal sinuses, orbital rims, nasal septum, ethmoid sinuses
Lateral view	--	Nasal bone, frontal sinuses, sella turcica, mandible
Basal view	Submentovertex	Mandible, zygomatic arches, and zygomatic bones
Towne view	Angled antero-posterior axial	Mandibular condyles and rami, maxillary sinuses, ethmoid sinuses, nasal septum, petrous ridge

Figure 5. Waters View (Occipitomental View)

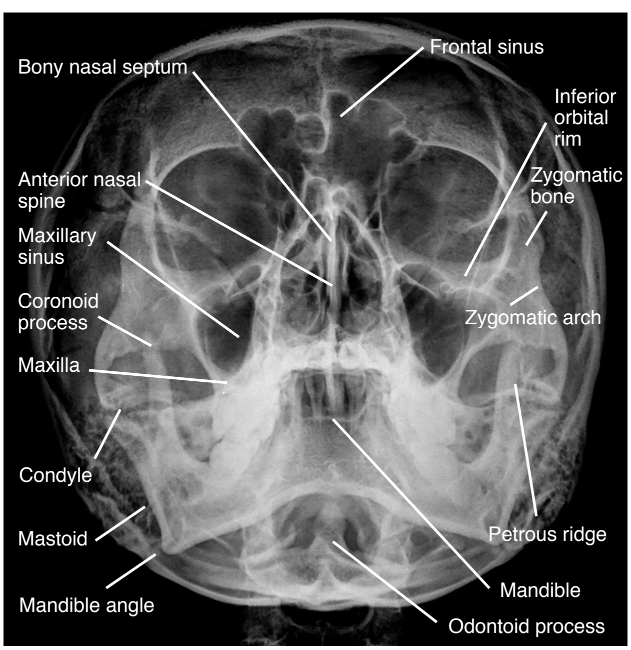
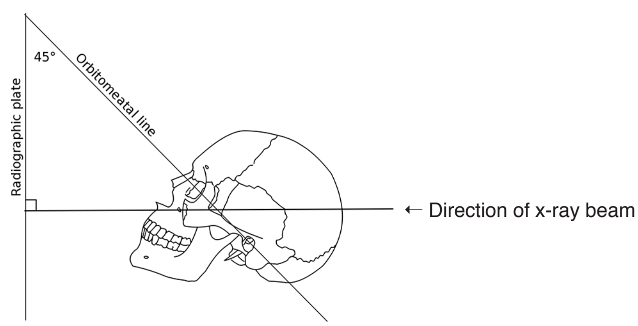
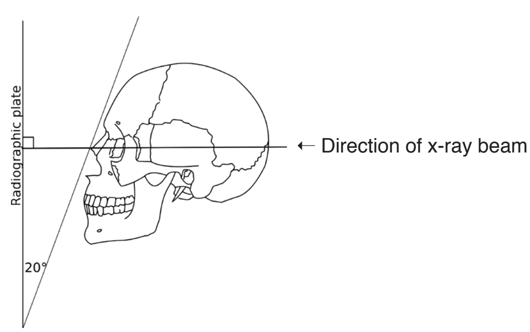


Figure 6. Waters View (Occipitomental)



Reprinted under the Creative Commons Attribution-Share-Alike 3.0 Unported license. Author Saurabh Patil. Available at: https://commons.wikimedia.org/wiki/File:Waters%27_view.svg

Figure 7. Caldwell View (Occipitofrontal)



Reprinted under the Creative Commons Attribution-Share-Alike 3.0 Unported license. Author Saurabh Patil. Available at: https://commons.wikimedia.org/wiki/File:Waters%27_view.svg fragment sign. Subcutaneous air is considered both a direct and indirect sign of facial fracture. When intracranial air is visualized, suspicion of a fracture of any cranium-adjacent bone should be raised. Other indirect signs of facial injury are fluid in the paranasal sinuses and soft-tissue swelling.[50] **Table 5** describes the direct and indirect signs of facial fractures.

Computed Tomography

High-resolution CT has become the first choice in imaging patients with maxillofacial trauma. The accurate assessment of bony stability, rotation, and fragment displacement aids surgeons in their overall repair planning.[30] CTs have become the standard of reference to determine which patients would benefit from surgical intervention.[51] In addition, soft-tissue assessment is more clearly defined on CT.

For the most accurate imaging of maxillofacial fractures by CT, the slice thickness must be narrow (ie, 0.625 mm on a 64-slice scanner) and performed with no intravenous contrast. The frontal sinuses to the mandible are included in a complete CT view.[51] Three-dimensional reconstructions can also be utilized for further evaluation of the patient's injuries.

Table 5. Radiographic Signs Consistent With Facial Fractures

Sign	Description
Direct Signs	
Nonanatomic linear lucency	Lower radiographic attenuation in a linear conformation visualized in an unexpected anatomical area
Separation sign (cortical defect)	Shows interruption in bone continuity and a small space produced by a cortical defect
Overlap sign	"Double density" produced when displaced fracture fragments overlap adjacent bone
Abnormal linear density	An opacity created when displacement of the lateral maxillary wall fragment is rotated in long axis
"Disappearing" fragment	Opposite of abnormal linear density sign; seeming dematerialization of displaced fragment due to rotation and alignment with x-ray beam
Indirect Signs	
Subcutaneous air	Can also be considered a direct sign; air infiltrating from violated ethmoid (periorbital air) or maxillary sinuses
Intracranial air	Created from fractures of the posterior frontal sinus wall, ethmoid, or sphenoid roof
Fluid in sinuses	Possible blood in sinuses, epistaxis, or from vessels adjacent to fractured bone segments
Soft-tissue swelling	Enlarged contour of the soft tissue, decreased radiolucency/increased opacity of area

This complementary technique increases the accuracy of visualizing inferior orbital wall fractures, locating loose bone fragments, and assessing the degree of displacement.[52]

As with plain films, the direct and indirect signs of fractures also aid in the evaluation of CT scans. Due to the nature of CT's ability to visualize soft tissue and related structures, direct trauma to the soft tissue of the face, periorbital injuries, and sinus or intracranial air are more easily detected. Air-fluid levels in the sinuses are also demonstrated on CT and can accurately distinguish blood from sinus fluid.

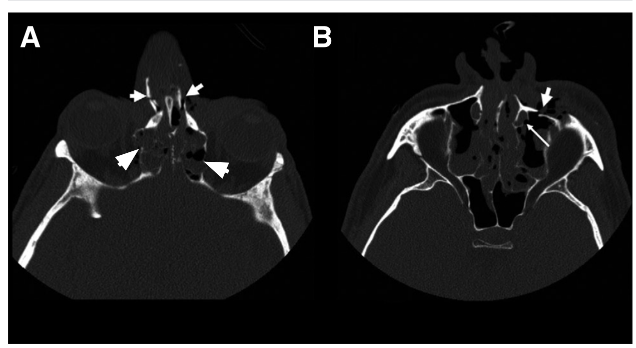
Imaging Of The Nose

When evaluating a patient for an isolated nasal bone fracture, diagnosis is usually made clinically and imaging is not commonly performed.[49] However, if imaging is deemed necessary, we recommend starting with a plain radiograph. Isolated fractures of the nasal tip are best visualized on an underexposed lateral view. A nasal arch fracture, on the other hand, is best seen on a Waters view.[50] **(See Figure 8.)**The presence of a nasal arch fracture, however, raises suspicion that the trauma is not isolated to the nasal bone. A nasal arch fracture may indicate that the naso-orbital-ethmoid complex has been compromised. CT is the imaging study of choice for accurate evaluation of a naso-orbital-ethmoid fracture.[51]

Imaging Of The Mandible

The mandible is a complete ring that is connected to both ends of the skull. Due to this ring conformation, finding a fracture in the mandible should prompt the emergency clinician to look for other injuries.[49] These

Figure 8. Bilateral Naso-Orbital-Ethmoid Complex Fractures



View A: Top arrows point to bilateral nasal fractures; bottom arrows point to impacted fractures of the ethmoid sinuses.
View B: Arrow points to disruption of bilateral laminae papyracea.
Laura L. Avery, Srinivas M. Susarta, Robert A. Novelline. Multidetector and Three-Dimensional CT Evaluation of the Patient with Maxillofacial Injury. *Radiologic Clinics of North America*. Volume 49, Issue 1, pages 183-203. Copyright 2011 with permission of Elsevier.
DOI: http://dx.doi.org/10.1016/j.rcl.2010.07.014

Clinical Pathway For Management Of Maxillofacial Trauma In The Emergency Department

Prehospital Notification
- Prepare for multitrauma patient **(Class indeterminate)**
- Notify appropriate ancillary services **(Class indeterminate)**
- Prepare for difficult airway **(Class indeterminate)**

→

Prehospital Care
- +/- cervical spine protection **(Class III)**
- Airway management **(Class II)**
- Endotracheal intubation preferred
- If necessary, rescue airway may be used to ventilate
- Apply pressure dressing to actively bleeding sites **(Class I)**

↓

Patient presents to the ED with facial trauma

↓

Perform Primary Survey
- Remove any foreign bodies in airway **(Class II)**
- Perform +/- jaw thrust or chin-lift maneuver **(Class II)**
- Prepare for endotracheal intubation or cricothyroidotomy **(Class II)**
- Check for pneumothorax **(Class II)**
- Establish wide-bore intravenous access **(Class II)**
- Assess for soft-tissue lacerations, such as scalp lacerations
- +/- nasal packing **(Class II)**
- +/- intraoral packing **(Class III)**
- Ensure placement of cervical spine collar **(Class III)**
- Be wary of distracting injuries **(Class III)**

↓

Perform Secondary Survey
- Fully disrobe patient to assess all injuries **(Class II)**
- Observe for facial asymmetry **(Class II)**
- Check for facial bone stability **(Class II)**
- Palpate all facial bones for tenderness, crepitus, or swelling **(Class II)**
- Check for CSF otorrhea or CSF rhinorrhea **(Class II)**
- Perform full ocular examination **(Class II)**
- Check dentition **(Class II)**
- If possible, perform a detailed cranial nerve examination **(Class II)**

↓

- Obtain appropriate imaging studies for potential injuries **(Class II)**
- Consult appropriate services
- Repeatedly re-examine patient **(Class II)**

Abbreviations: CSF, cerebrospinal fluid; ED, emergency department.

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
- Nonrandomized or retrospective studies: historic, cohort, or case control studies
- Less robust randomized controlled trials
- 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

This clinical pathway is intended to supplement, rather than substitute for, professional judgment and may be changed depending upon a patient's individual needs. Failure to comply with this pathway does not represent a breach of the standard of care.

injuries and the associated fractures or dislocations are described as coup-contrecoup injuries.

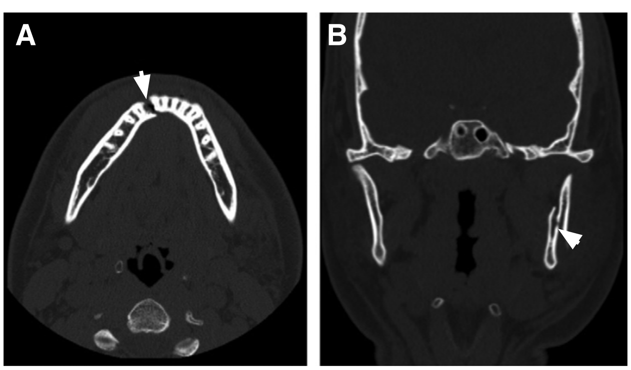
Plain radiographic views of the mandible normally include an anteroposterior projection, lateral oblique films, and a reverse Towne view. However, the most useful plain film study is the panoramic radiograph. A panoramic x-ray machine scans across the entire span of the mandible, and is able to exhibit a complete view of the mandible in a single film. **(See Figure 9.)**

Although the panoramic view is highly sensitive, with one study reporting a sensitivity of 92% in detection of mandibular fractures,[53] CT is still the best imaging modality for identification of mandibular fractures, with a sensitivity of 100%.[54] Therefore, patients with a suspected mandibular fracture should directly obtain a CT. **(See Figure 10.)**

Figure 9. Panoramic View Of Jaw Fractures

Arrows point to right mandibular angle and left mandibular body fracture following a punch to the jaw.
Used with permission of Dr. Eric Heffernan. Available at: http://www.svuhradiology.ie/case-study/mandibular-fractures-opg/

Figure 10. Fractures Of The Right Parasymphysis And The Left Mandibular Ramus



View A: Arrow points to fracture of right parasymphysis.
View B: Arrow points to left mandibular ramus fracture.
Laura L. Avery, Srinivas M. Susarta, Robert A. Novelline. Multidetector and Three-Dimensional CT Evaluation of the Patient with Maxillofacial Injury. *Radiologic Clinics of North America.* Volume 49, Issue 1, pages 183-203. Copyright 2011 with permission of Elsevier.
DOI: http://dx.doi.org/10.1016/j.rcl.2010.07.014

Imaging Of The Orbits

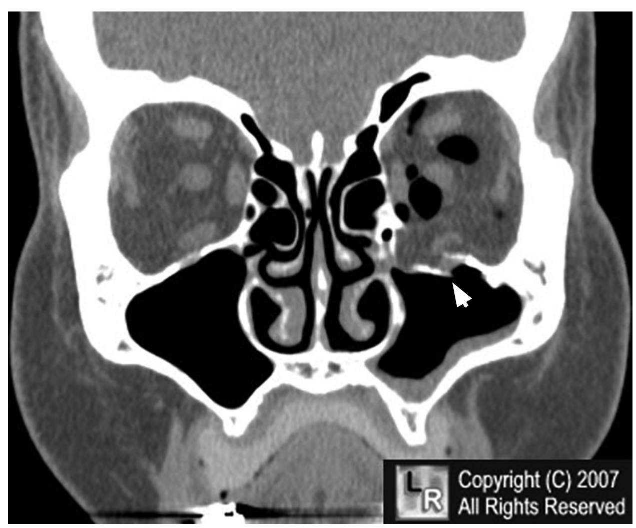
The term, *blowout fracture* (also known as an orbital floor fracture), commonly refers to fractures to any wall of the orbit, which may or may not spare the orbital rim. The majority of blowout fractures can be found on plain radiographs, namely in the Waters and Caldwell views.[50]

Although identification of a blowout fracture may be initially made on a plain radiograph, further assessment of the degree of damage to the orbital floor and the surrounding structures is better performed by CT. CT imaging in both the axial and coronal planes helps surgeons decide whether the injury warrants an operative plan. Globe entrapment may be a consequence of a blowout fracture, due to herniation of the inferior or medial rectus muscles into the maxillary and ethmoid sinuses, respectively. **(See Figure 11.)** On CT, evidence of entrapment can be seen as a sudden and abrupt kink in the muscle.[55]

Another possible serious consequence is a retrobulbar hemorrhage. Although surgical decompression is usually based on clinical findings, early detection of a retrobulbar hemorrhage on CT may allow for more vigilant observation of its progression.[56]

Blow-in fractures (also known as orbital roof fractures) usually include the orbital rim, as a result of a direct blow to the supraorbital rim. Another mechanism is a direct blow to the frontal bone. Because the orbital roof is thinner and weaker than the frontal bone, the force of the direct blow may be transmitted to the roof, resulting in a collapse of the structure into the orbital space, which can be seen

Figure 11. Coronal CT Of A Blowout Fracture Of The Orbit



Abbreviation: CT, computed tomography.
Arrow points to fracture of the floor of the left orbit.
Used with permission www.learningradiology.com and Dr. William Herring. Available at: http://learningradiology.com/archives2007/COW%20262-Blowout%20fracture/blowoutfxcorrect.html

on CT. CT can also visualize whether the orbital roof fracture extends into the apex of the orbit where the cranial nerves enter, causing damage to CN II, III, IV, V, and/or VI.[57] Fractures of adjacent structures, such as the anterior cranial fossa or the posterior wall of the frontal sinus, can be associated with the presence of intracranial air on CT.

Imaging Of The Zygoma

The underexposed basal view, or the "bucket handle" view, is preferred for visualization of the zygomatic arch and body. Fractures are also demonstrated on the Waters view, where the "elephants of Rogers" and the lines of Dolan can be traced. The elephants of Rogers is the appearance of an elephant's head and trunk formed by the combination of the zygomatic and maxillary lines. The lines of Dolan include the orbital line, the zygomatic line, and the maxillary line.[50,58] **(See Figure 12.)**

A more complex injury pattern involves disruption at the zygomaticofrontal suture, zygomaticomaxillary/zygomaticosphenoid, and the zygomaticotemporal connections. Together, this fracture pattern is termed a "tripod fracture," "tetrapod fracture," or a zygomaticomaxillary complex fracture. Tripod fractures can be visualized on the Waters view, the Caldwell view, and the Towne view.[50] As with other facial fractures, a more detailed view is likely to be seen on CT.[59] **(See Figure 13.)**

Imaging Of The Maxilla

The classification of Le Fort fractures depends on the plane of the fracture and the degree of separation of part or all of the maxilla from the adjacent facial bones.[50] All Le Fort fractures will have disruption of the pterygoids from the maxilla.[31]

For Le Fort I fractures, the lateral view will show the pterygoid processes and posterior maxillary walls, while a fracture that travels across the bilateral maxilla is best seen on Waters view. In Le Fort II fractures, the Waters and lateral projections are the best views for demonstrating the facial bone separation. In Le Fort III fractures, the midface has essentially no remaining intact connection to the base of the skull. Since this fracture may occur in association with severe skull injury, it is highly recommended that CT be utilized when a Le Fort III injury is suspected.[31,50,51,56]

Imaging Of The Frontal Sinus

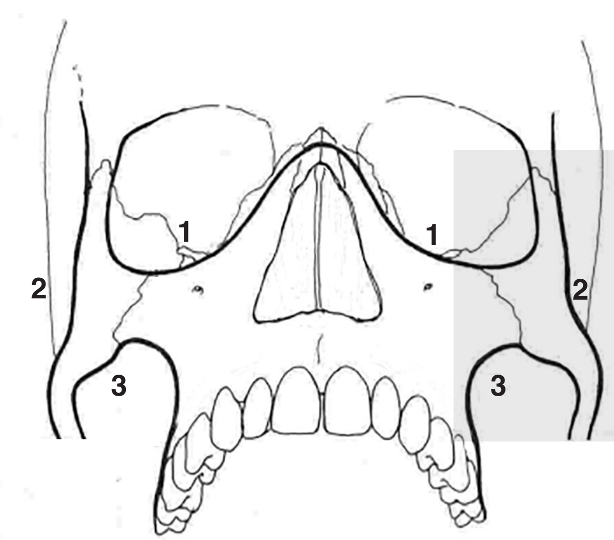
Due to a greater amount of force required for frontal bone fractures, they can be associated with intracranial and skull-base injuries. Intracranial complications can include intracranial hemorrhage or pneumocephalus.[60] A head CT would be able to demonstrate whether the posterior table and/or anterior table has been compromised, as well as associated intracranial complications. If there is a suspicion for frontal sinus fractures, CT of the head and the facial bones should be obtained.

Treatment

Nasal Fractures

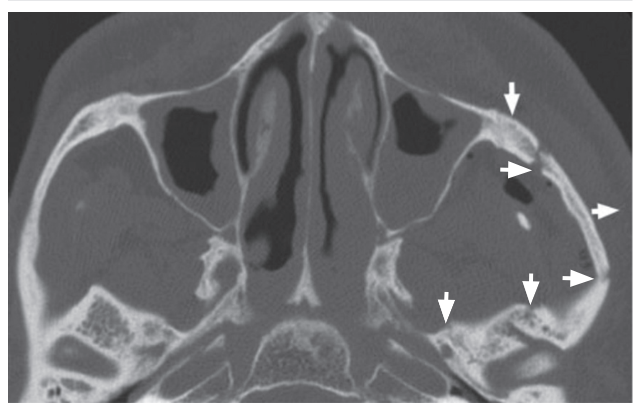
If possible, information should be obtained on any previous surgeries, injuries, and subjective assessment of

Figure 12. Waters View With The Lines Of Dolan And The Elephants Of Rogers



The lines of Dolan are marked as 1, 2, and 3. Lines 2 and 3 form what appears as a profile of an elephant's head and trunk, known as the elephants of Rogers.

Figure 13. CT Scan Of Zygomaticomaxillary Complex Fracture, Left Upper Maxilla



Arrows point out fractures.

Abbreviation: CT, computed tomography.

Richard A. Hopper, Shahram Salemy, Raymond W. Sze. Diagnosis of Midface Fractures with CT: What the Surgeon Needs to Know. *RadioGraphics*. Volume 26, Issue 3. With permission of the Radiological Society of North America.

DOI: http://dx.doi.org/10.1148/rg.263045710 baseline nasal function and appearance for any patient presenting with a potential nasal fracture.[18]

A thorough internal examination for nasal fracture is necessary to facilitate evaluation for septal hematoma and may be accomplished with adequate lighting, suction, anesthesia, and vasoconstrictive nasal sprays. Prior studies have shown that septal abscesses (which are potential sequelae from septal hematomas, if left untreated) may lead to perforation or permanent saddle-nose deformity. Therefore, if identified, a septal hematoma should be incised, aspirated, and packed immediately.[18,61] (For a video demonstration of treatment of septal hematoma, scan the QR code below or go to: https://www.youtube.com/watch?v=wPB5XXfhyP8)

Treatment for nasal injuries may initially begin with the same management as any soft-tissue injury. Copious irrigation is necessary for contaminated wounds. Any mucosal lacerations should be noted and repaired. If an uncomplicated nasal fracture is diagnosed, treatment is conservative, with pain medication, rest, ice, and head elevation. No clinical evidence currently exists to support early nasal fracture reduction. Follow-up evaluation and management after swelling has resolved is advisable. Early and late complications associated with nasal fractures include meningitis, diplopia, mucoceles, brain abscesses, frontal bone osteomyelitis, chronic frontal headaches, and cosmetic deformities.[19]

Identifying the source and location of nasal bleeding is important, as this may aid in initiating the appropriate treatment protocol.[18] Epistaxis treatment may begin with silver nitrate cauterization. In a retrospective review of 353 patients presenting with primary anterior epistaxis, silver nitrate cauterization had the highest success rate, at 80%.[62]

Nasal packing may be necessary for epistaxis that is unresponsive to cauterization. Anterior or posterior packing (or both) may be necessary. In both cases, adequate anesthesia and vasoconstriction is employed. Various packing materials are available for anterior packing, including traditional Vaseline® gauze packing, compressed sponge/tampon, (ie, Merocel® sponges), anterior epistaxis balloons (ie, Rapid Rhino®), etc.[62] The appropriate management will depend on supplies available.

Link To Video Showing Treatment Of Septal Hematoma

Scan the QR code with a smartphone or tablet or go to: https://www.youtube.com/watch?v=wPB5XXfhyP8

It is recommended that all packing be removed within 3 to 4 days, and that prophylactic antibiotics be administered to all patients, due to concern for toxic shock syndrome. However, the incidence of toxic shock syndrome after packing for epistaxis is unknown. In a study by Jacobsen et al, there was a rate of 16.5 cases of toxic shock syndrome per 100,000 patients who underwent nasal surgery and had nasal packing. No data exist that indicate that the use of prophylactic antibiotics would reduce this incidence.[63] If bleeding is controlled and it is the sole injury, patients may be discharged home with follow-up arranged with an ear, nose, and throat specialist within 48 to 72 hours for packing removal.

Epistaxis that continues after anterior packing may require posterior packing; however, management may be difficult due to the relatively inaccessible site of bleeding. Classically, posterior packing has been achieved with rolled gauze. In a retrospective study of 81 patients with posterior epistaxis who had posterior packing placed, 21% experienced acute sinusitis, 12% required blood transfusion, and 4% required intubation.[64] Therefore, patients with posterior packing require admission to a closely monitored setting for pain management and because of an increased risk for hypoxia, hypoventilation, and dysrhythmias.[64] Antibiotics are also recommended to prevent rhinosinusitis and toxic shock syndrome.

The more recent development of double-balloon catheters consisting of an anterior and posterior balloon are preferred for their ease of use. The catheter is inserted into the back of the nasopharyngeal space, and the posterior balloon is inflated first with saline, and then the anterior balloon is inflated with saline. A 10 to 14 French Foley catheter with a 30 mL balloon can be used as an alternative. If all above treatment strategies fail, patients may require arterial ligation or embolization, necessitating consultation with an ear, nose, and throat specialist.

Mandibular Fractures

Prescribing antibiotics for mandibular fractures is common; however, current evidence supporting its use is poor. In a study by Panayiotis, the occurrence of postoperative infection after repair of mandibular fractures ranged from 4.5% to 62% if no antibiotics were given, and from 1.9% to 29.4% for patients who received antibiotics.[23] In a systematic literature review study by Mundinger et al, preoperative, but not postoperative, antibiotic use was recommended for comminuted mandibular fractures, particularly in patients with confounding injuries, to prevent further infection.[24] However, there have been no prospective randomized studies to prove the efficacy of this recommendation. Cephalosporins, penicillin, clindamycin, and metronidazole are most frequently used, but no reliable evidence exists to support the type and dosage of antibiotics to use.

Orbital Fractures

Patients with simple blowout fractures without eye injury can be discharged home with appropriate consultation with ophthalmology, even if signs of entrapment are present. These ocular injuries will normally have complete resolution of swelling. Patients with serious eye injuries and decreased visual acuity should have emergent ophthalmology consultation. Initial management of patients presenting with orbital trauma includes application of ice to the affected area for the first 48 hours, elevation of the head of the bed while sleeping, nasal decongestants, a broad-spectrum antibiotic (such as amoxicillin clavulanate), nonsteroidal anti-inflammatory medications, and avoidance of nose-blowing and Valsalva maneuvers (so as not to increase intraorbital pressure).

Patients should be instructed to return if they note a change in visual acuity, have increased pain, or if they see flashing lights. Indications for performing early surgery include diplopia, enophthalmos, or substantial soft-tissue herniation into the maxillary sinuses.[26]

Orbital Compartment Syndrome

Patients should be fully assessed for possible orbital compartment syndrome (OCS). OCS is an uncommon ophthalmologic surgical emergency that is caused by an acute rise in orbital pressure. When pressure within the orbit increases, damage to ocular and intraorbital structures may occur and result in irreversible blindness. OCS is a clinical diagnosis, and early recognition is necessary to allow for emergent orbital decompression. Physical examination findings may develop within minutes to hours and can include acute onset of decreased vision, painful periorbital edema, or proptosis. Patients should be questioned on whether or not they are on antiplatelet, blood-thinning, or thrombolytic medications. The treatment options for OCS include lateral canthotomy and emergent ophthalmologic consultation.[28]

Zygoma Fractures

Displaced zygoma fractures require treatment within 10 days. Untreated fractures may cause cosmetic deformity or limited mandibular movement. Patients should be instructed to avoid nose-blowing and to apply pressure to the affected side.

Special Populations

Pediatric Patients

Maxillofacial trauma is less common in children than in adults, likely due to the flexibility of the less-calcified pediatric facial bones, a larger skull-to-face ratio, lack of pneumatization of the sinuses, and the protective fat pads of infants and young children.[15,16,65] Nasal fractures in children are the most common facial fracture, but are frequently missed, due to a smaller nasal prominence. Mandibular fractures are the second most common fractures in children.[65]

Pediatric facial fractures are more likely to be missed on plain facial radiographs. In one study, frequently missed fractures on plain film were of the ethmoid and sphenoid bones, the maxilla, the zygoma, and the orbit. All of the missed fractures were detected on CT.[66]

Elderly Patients

The incidence of maxillofacial trauma in elderly patients is on the rise. This may be due, in part, to an aging population and their more active lifestyles. Because of the fragility of the aging body and bones, even minor trauma can cause major injuries. The 2 most frequent causes of maxillofacial trauma are falls and motor vehicle crashes.[67]

In the elderly population, the upper mid-face is the most frequently fractured. One study reported that nasal bones were the most likely to be fractured,[6] while another reports that the zygoma was most commonly fractured in older patients.[68] The second most commonly fractured facial bone is the mandible. Loss of teeth may lead to atrophy of the bone and reduction in the vascularity of the mandible, which, in turn, decreases mandibular strength.[69]

Controversies And Cutting Edge

Routine Use Of Antibiotics

The use of prophylactic antibiotics has been controversial. Theoretically, there is a higher exposure to bacterial contamination during a facial fracture due to its proximity to the oral cavity, sinuses, and nasal passages. Several studies have reported a decrease in infection rates in mandibular, zygomatic, and Le Fort fractures when patients were given antibiotics perioperatively.[70,71]

In a recent multidisciplinary survey that evaluated the prescribing habits of plastic surgeons; ear, nose, and throat surgeons; and oral and maxillofacial surgeons, 85% always gave patients antibiotics.[71] However, the duration of the antibiotic regimen used was not consistent. Current evidence has shown that giving antibiotic prophylaxis beyond 24 hours perioperatively or postoperatively had no significant additional benefit to the patient.[71]

Transcatheter Arterial Embolization To Control Bleeding

Life-threatening hemorrhage from maxillofacial trauma is rare. If direct pressure is unsuccessful, reduction of the fracture may be necessary to control bleeding. Transarterial embolization (TAE) is an alternative to surgical exploration and arterial ligation.[72] Although not a new technique, TAE is either underused or its use is underreported. However, when more conservative interventions fail and the trauma patient is hemodynamically unstable, it has been recommended that TAE be considered immediately, before any other surgical interventions.[73] TAE has been reported to be highly successful in controlling facial hemorrhage. Of the trauma patients who underwent TAE in 2 different studies, all had bleeding successfully controlled.[73,74] Complications can include cerebrovascular accident, facial nerve palsy, soft-tissue necrosis, trismus, and tongue-tip necrosis.[74]

Use Of Ultrasound In Diagnosis Of Maxillofacial Injuries

Ultrasound is noninvasive, does not use radiation, and is fast. Another advantage of ultrasound is its relatively low cost and its portability, which allows for its availability worldwide. Since 1981, there have been multiple studies reporting the diagnostic accuracy of ultrasound when assessing for facial fractures. The sensitivity for detection of nasal bone fractures is 90% to 100%, with a specificity of 98% to 100%.[73] **(See Figure 14.)** Orbital fractures are also frequently investigated with ultrasound, mostly focusing on medial, lateral, and orbital floor fractures. In general, the accuracy of identifying orbital wall fractures is 90% to 100%.[75] With orbital floor fractures, the sensitivity is 85% to 100% and specificity is 57% to 100%.[76] Another area that has been examined is the inferior orbital rim, with a sensitivity of 94% and specificity of 92%.[75] When assessing for injury, fractures that are subtle and nondisplaced are more difficult to detect with ultrasound.[76-78] Another limitation of ultrasound in maxillofacial fractures is in evaluating complex facial fractures involving multiple adjacent facial bones.[75]

Disposition

Surgical repair of facial fractures is often delayed due to its nonemergent nature. Maxillofacial trauma patients will rarely be taken to the operating room from the ED unless they also have a concurrent injury that needs emergent intervention. Most facial fractures will be repaired within a few days, but some may even be delayed a few weeks without significant complications.

Consultation

Any complex facial fracture should prompt the emergency clinician to obtain a consultation from an oromaxillofacial or plastic surgeon. Urgency of the consultation depends on the degree of fracture complexity, displacement of fracture fragments, and concurrent injuries. Other consultants that may be needed are ophthalmology and neurosurgery. Ophthalmology will need to be consulted for any maxillofacial trauma patient with changes in visual acuity or any vision-threatening injuries, such as retrobulbar hemorrhage, traumatic optic neuropathy, globe injuries, loss of eyelid integrity, or severe chemical injury to the eye. Patients with intracranial involvement should be evaluated by neurosurgery. Patients with cervical spine injuries will need to be evaluated by neurosurgery or an orthopedic spine specialist. Consider early involvement of a multidisciplinary trauma team for patients with severe maxillofacial trauma. Patients who have suffered multisystem trauma in addition to maxillofacial trauma will need to be stabilized and transferred to a trauma center if the appropriate consulting services are not available at the initial site.

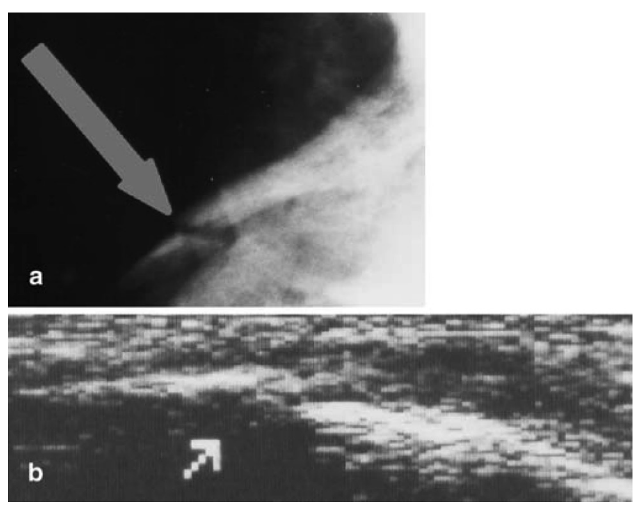
Admission

Patients with severe and complex maxillofacial injuries will likely be admitted to the hospital. Some of these patients will have concurrent injuries that may need prolonged observation or urgent intervention. A patient's medical comorbidities or social circumstances may also be a factor in whether a patient with facial injuries will need to be admitted.

Discharge

The awake and alert patient with isolated nasal or mandibular injuries will likely be discharged. However, the emergency clinician needs to ensure that the patient is able to care for himself or herself or has adequate home care. The patient will be instructed

Figure 14. Radiograph And Ultrasound Of A Nasal Bone Fracture



View A is a radiograph showing a break in the bony cortex.
View B is an ultrasound of the same fracture.
Clinical Oral Investigations. Potentials of Ultrasound in the Diagnosis of Midfacial Fractures. Volume 7, Issue 4, 2003; pages 226-229. R.E. Friedrich. With permission of Springer.
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Risk Management Pitfalls For Maxillofacial Trauma

1. **"The patient's injuries seemed isolated to the orbital and nasal region, so I only performed a maxillofacial CT."**
   Severe maxillofacial trauma may be associated with head trauma and intracranial pathology. This is especially important in patients who have altered mental status or are unable to give a history. Facial fractures may extend into the base of the skull.

2. **"The patient didn't complain of any neck pain, so I didn't order a cervical spine CT."**
   Even soft-tissue injuries to the maxillofacial region may have associated injuries to the cervical spine. Injuries to the midface are most likely associated with C5-C7 disruption, while injuries to the lower face are likely associated with C1-C4 disruption.[79]

3. **"I didn't notice any obvious injuries in the mouth, so I didn't think to check for missing teeth."**
   Dental injuries occur frequently with maxillofacial trauma. Mandibular fractures and Le Fort fractures are more likely to have associated dental injuries.[80] If a trauma patient appears to have a newly missing tooth, consider aspiration. Signs of a missing tooth include an empty socket, possibly with bleeding, or remnants of a fractured tooth. Consider a radiograph of the soft-tissue neck and chest to assess for aspirated teeth.

4. **"Both of the patient's eyes were swollen, so I couldn't assess for extraocular movements."**
   In an alert patient, make sure to perform a complete neurological examination. If the patient complains of diplopia, consider further imaging. Diplopia should raise suspicion of entrapment from a blowout fracture. CT of the facial bones will demonstrate whether any of the orbital walls or the orbital floor have been fractured. An abnormal neurological examination should also prompt assessment of the patient for intracranial trauma. Remember that ultrasound may be used to assess for extraocular movements in patients unable to open their eyes due to swelling.

5. **"The patient's nose keeps running. I'm not sure why."**
   CSF rhinorrhea should be considered if there is persistent nasal discharge. Once confirmed, a CT of the head and facial bones should be ordered to evaluate how the cranium has been violated. A neurosurgical consultation is required.

6. **"I didn't notice any obvious bleeding or injuries inside the patient's nose."**
   Patients who have had blunt trauma to the nasal area are at risk for developing septal hematomas. A missed septal hematoma may lead to septal necrosis, perforation, or abscess and disfigurement. A septal hematoma should be incised, drained, and packed during evaluation.

7. **"The patient keeps bleeding from somewhere inside his mouth, but I'm not sure where it's coming from."**
   The tongue has an extensive blood supply, and deep or complex lacerations may cause enough bleeding to obscure the physician's view while evaluating the mouth. More importantly, persistent bleeding from the tongue could obscure the oropharynx, possibly complicating airway management.

8. **"I did my primary survey. The patient's airway appears intact."**
   Once a patient is stabilized initially and appears to have an intact airway, re-evaluate the patient multiple times to ensure that soft-tissue edema or hematomas have not developed to the point of airway compromise. In a patient who is at high risk for developing airway compromise due to third-spacing, intubation may need to be considered early in ED management.

9. **"I placed a nasal catheter to stop the patient's epistaxis, but now his face looks more swollen."**
   While attempting to control intractable epistaxis, especially from posterior sources, inflatable nasal packing is usually utilized. However, in naso-orbital-ethmoid complex fractures or midface fractures, overinflated nasal packing may displace fracture fragments, causing more injury.

10. **"The parents' story seems a little off. They must be very upset and emotional because their child is injured."**
    With any trauma, it is exceedingly important to be aware of signs that could point to underlying abuse. Consider abuse when the history of trauma is inconsistent with the injuries.

to follow up with the appropriate specialties to monitor healing, as well as to schedule further interventions, if necessary. Patients should be warned that swelling of the injured areas may persist for many days, but may be improved with ice application and elevation.

Summary

Maxillofacial trauma is one of the most frequently encountered injuries in the ED, and its incidence is likely to continue to increase in the future. The topic of maxillofacial injuries is extremely broad and covers everything from soft-tissue lacerations to complex fracture patterns and associated injuries. The emergency clinician must be cognizant of all potential injuries when dealing with such patients and apply a simple, but inclusive treatment algorithm. Particular attention should be paid to airway management, including clearing the airway, ensuring adequate ventilation, and monitoring circulatory status. Make sure to fully disrobe the patient and to examine for potential concomitant injuries, such as intracranial or cervical spine injuries. Awareness of injury patterns on traditional radiographs, CT, and ultrasound are also helpful in the management of patients.

Case Conclusions

With your first patient of the night, you quickly assessed that you needed to place an emergent airway. After getting the patient onto the stretcher, you applied a cervical spine collar and attempted to arouse him. He was unresponsive, and you noted a gross amount of bleeding coming from his mouth. After proper suctioning and positioning of the patient, you were able to visualize inside his mouth and identify several loose teeth, and you removed them with Magill forceps. You noted that his tongue appeared to be obstructing his airway, so you used a simple jaw-thrust maneuver, and his oxygen saturation improved. You ensured that no further foreign bodies were present, and then used the rapid sequence intubation technique to perform an endotracheal intubation. You ordered a chest x-ray that identified several loose teeth in the trachea. You then proceeded with further assessment of the patient's injuries.

Meanwhile, your second patient had quickly decompensated after being initially combative. His repeat vital signs were concerning for hypotension, tachycardia, and hypoxia. You quickly undressed him as your nursing staff placed him on a monitor and established large-bore IV access. You immediately identified a large scalp laceration that was bleeding profusely. You asked your resident to apply pressure and staple the wound as you prepared to endotracheally intubate the patient. As you tried to intubate him, you noticed blood seeping bilaterally from his nares and posterior oropharynx. You aggressively suctioned the posterior oropharynx and successfully intubated him. You then inserted bilateral anterior nasal packing, and the bleeding from the nares and posterior oropharynx slowed. After a full examination in the trauma bay and improvement in his vital signs, you sent the patient to radiology for further imaging with the trauma team in tow.

Your third patient stated that she had been punched on the left side of her face and complained that she was having pain and decreased sensation along the left side of her jaw and lower lip. She noted difficulty closing her mouth fully and mentioned that she had a small swelling under her tongue. On examination, you felt crepitus along the bottom of her left jaw but observed no step-offs, malocclusion, mobility, loose dentition, or intraoral bleeding. You saw a small sublingual hematoma, and she failed the tongue-blade test. You sent her to CT on the suspicion that she had sustained a mandibular fracture. The results of the CT confirmed your suspicion. After speaking with an oromaxillofacial surgeon, you decided to send her home with oral antibiotics, pain medication, and advice to follow a soft diet, and to make a follow-up appointment with an oral and maxillofacial surgeon within 24 hours. With your ED tracker finally empty, you went to get that third cup of coffee…

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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 is included in bold type following the reference, where available. The most informative references cited in this paper, as determined by the authors, are noted by an asterisk (*) next to the number of the reference.

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1. **A patient presents after a baseball-bat injury to the side of his face. He is complaining of difficulty opening his mouth. Of the following injuries, the patient most likely sustained which type of injury?**
   a. Frontal sinus fracture
   b. Zygomatic arch fracture
   c. Exacerbation of temporomandibular junction disorder
   d. Nasal bone fracture

2. **What bone is absent at birth, radiographically identifiable at age 8, and matures at age 15?**
   a. Symphysis
   b. Zygoma
   c. Frontal sinus
   d. Sphenoid

3. **An intoxicated patient presents with severe maxillofacial injuries. She is initially communicating with the staff, but then suddenly becomes unresponsive and cyanotic. The most appropriate intervention at this time is to:**
   a. Ensure that no foreign bodies are present within the oral cavity.
   b. Insert a laryngeal-mask airway or other temporizing airway device.
   c. Perform rapid sequence intubation and endotracheal intubation.
   d. Place the patient on a cardiac monitor and nasal oxygen and re-examine after 15 minutes.

4. **Which of the following examination findings in a patient with a suspected nasal bone fracture should prompt immediate intervention?**
   a. Clear rhinorrhea
   b. Subcutaneous emphysema along the nasal bone
   c. Limited extraocular movements
   d. Mental status changes
   e. All of the above

5. **Which of the following fractures is LEAST likely to be the cause of a cerebrospinal fluid leak?**
   a. Ethmoid
   b. Zygoma
   c. Maxilla
   d. Mandible

6. **What is the most useful radiographic image of the mandible?**
   a. Waters view
   b. Caldwell view
   c. Towne view
   d. Panoramic view

7. **A patient presents after being punched in the left eye. He is now complaining of double vision and, on examination, is noted to have limited ability to look medially. The patient has most likely sustained a(n):**
   a. Frontal sinus fracture
   b. Orbital blowout fracture
   c. Intracranial hemorrhage
   d. Optic neuritis

8. **After further examination, the patient in Question 7 who was punched in the eye and has double vision and limited ability to look medially is determined to NOT have an eye injury. What is the appropriate disposition of this patient?**
   a. Ophthalmology should be consulted emergently.
   b. The patient should be immediately taken to the operating room by ophthalmology.
   c. Intravenous antibiotics should be administered and the patient admitted.
   d. Perform a lateral canthotomy.

9. A patient presents with blunt facial trauma. On further evaluation, he is noted to have a fluctuant white mass within his left nare. What is the appropriate next management step?

a. Discharge patient home with ear, nose, and throat follow-up.
b. Prescribe antibiotics and discharge home.
c. Incise the mass, aspirate the contents, and apply packing to the area.
d. Administer intravenous antibiotics and admit the patient.

10. All of the following are reasons for the reduced incidence of pediatric maxillofacial fractures EXCEPT:

a. Smaller skull-to-face ratio
b. Flexibility of pediatric facial bones
c. Protective fat pads of infants and young children
d. Lack of pneumatization of the sinuses

Coming soon in *Emergency Medicine Practice*

Acute And Decompensated Heart Failure In The Emergency Department: Recognition Of The Different Types And Selecting Optimal Management Strategies

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Not all heart failure is the same. Heart failure with preserved ejection fraction and heart failure with reduced ejection fraction represent distinctly different underlying pathophysiology that will require different approaches in stabilization and treatment. With the prevalence of heart failure in elderly patients growing along with the aging of the population, managing patients with heart failure in the emergency department can be a challenge. Advances in diagnostic techniques and new treatment options require that emergency clinicians stay up to date to offer the best care in stabilizing and beginning treatment of these acutely sick patients.


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Abstract

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- Decompensated Heart Failure
- Renal and Genitourinary Trauma
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Target Audience: This enduring material is designed for emergency medicine physicians, physician assistants, nurse practitioners, and residents.

Goals: Upon completion of this activity, 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 presentations; and (3) describe the most common medicolegal pitfalls for each topic covered.

Objectives: Upon completion of this activity, you should be able to: (1) describe the pattern of potential maxillofacial injuries sustained after facial trauma; (2) assess possible complications associated with maxillofacial injuries, including airway management and hypotension; and (3) list imaging studies available to fully assess for maxillofacial trauma.

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