Anatomy\textsuperscript{1,2,3}

The mandible is divided into eight regions. The symphysis is located in the midline, joining the right and left halves of the mandible. The parasymphyseal region is located on either side of the symphysis, and spans from canine to canine. Moving posterolaterally, the body is the region from the canine to the angle, which is the non-tooth bearing region between the body and the ramus. The ramus is the vertical portion of the mandible that extends from the angle toward the zygomatic arch, terminating at the coronoid process and condyle. The condyle articulates with the glenoid fossa, providing the pivot point for motion of the mandible. The mandibular notch is located between the condyle and the coronoid process. The inferior alveolar nerve travels through the ramus, angle, and body, and terminates as the mental nerve, which exits the mandible through the mental foramen (located between the first and second premolars) to provide sensation to the ipsilateral lower lip and chin. There are three weak points of the mandible that often dictate where a mandible fracture will occur. These weak points are the neck of the condyle, the angle, especially if a third molar is present, and the mental foramen.

\textit{(See slides for images)}

Occlusion\textsuperscript{1,2}

Occlusion is the way in which one’s maxillary and mandibular teeth relate to each other when the jaw is closed. When treating fractures of the mandible, the first and primary objective is to reestablish the patient’s premorbid occlusion. When viewing a tooth, such as a molar, the cusps further from the lips are referred to as distal and the cusps closer to the lips are referred to as mesial. The lateral cusps abutting the buccal mucosa are referred to as buccal and the cusps closest to the tongue are referred to as lingual (see slides for an excellent illustration). Angle’s classification is most commonly used to define a patient’s occlusion and has three classes. In Class 1 occlusion the mesiobuccal cusp of the maxillary first molar rests within the mesiobuccal groove of the mandibular first molar. In Class 2 occlusion (retrognathism) the maxillary first molar is more anterior in relation to the mandibular first molar. In Class 3 occlusion (prognathism) the maxillary first molar is more posterior in relation to the mandibular first molar. Two other malocclusions are open bite and crossbite. In open bite, when the patient closes his or her jaw as much as possible some teeth occlude while a gap is left between others. This usually occurs anteriorly between the incisors and canines or posteriorly between the molars and is often the result of a fracture or poorly healed fracture. Crossbite refers to an abnormal medial/lateral relationship between a patient’s maxillary and mandibular teeth. The normal relationship between these
teeth is for the maxillary buccal cusps to lie lateral to the mandibular buccal cusps. In lingual crossbite, the maxillary buccal cusps are positioned medially, such that the cusps of the teeth are end-to-end, or worse, the maxillary cusps lie between the buccal and lingual cusps of the mandibular teeth. In buccal crossbite, the maxillary buccal cusps are positioned far laterally to the mandibular buccal cusps (please see slides for illustrations).

**Classification of Mandible Fractures**

Mandible fractures can be classified in several ways. Standard fracture nomenclature for long bone fractures is the first classification (simple, compound, comminuted, or greenstick). The second method is by anatomic location. The third is by dentition status, and the fourth is by stability of the fracture, i.e. favorable versus unfavorable. In a simple fracture the oral mucosa and external skin are intact. In a compound or open fracture there is a laceration of the mucosa or skin present, or the fracture passes through a tooth root. Comminuted fractures have multiple bone fragments. Greenstick fractures involve only one cortex of the bone and occur most commonly in children.

Mandible fractures occur most commonly in the region of the condyle, the body, or the angle. The condylar region is subdivided into the head, neck, and subcondylar regions, with most condyle fractures being subcondylar.

In terms of dentition status, the patient is either dentulous or edentulous, or pediatric. Having a full set of adult teeth makes for the most straightforward fracture reductions. In the edentulous patient, there are several changes in the mandibular bone that must be considered. First, there is decreased mandibular height due to resorption of the alveolar ridge; this leads to decreased blood supply to the remaining bone. Second, the mental foramen assumes a superficial location due to the resorbed bone. Finally, one advantage in the edentulous patient is that the accuracy of the re-approximation of the fracture becomes less important as there are no teeth to align. In the pediatric patient, unerupted dentition much be carefully avoided when placing any screws; the deciduous teeth that are present also hold wire poorly.

Fractures can be classified as favorable or unfavorable based on the stability (or lack thereof) afforded by the pull of muscles on the fractured segments of bone. The temporalis and masseter muscles provide the primary upward force while the downward force is provided by the suprahoid musculature and gravity. If these forces serve to bring the fracture line together, the fracture is favorable; if they serve to pull the fracture line apart, the fracture is unfavorable.

**Patient Evaluation**

Mandible fractures are almost universally found in the setting of trauma, and as such, ATLS principles (ABCs) should be observed during the initial patient evaluation. Of particular interest to the otolaryngologist is the airway. Bilateral mandible body fractures can result in airway obstruction as the anterior portion of the mandible can become displaced posteriorly, and with it the support for the base of tongue, which ultimately obstructs the airway. Other sources of airway compromise include concomitant laryngeal or tracheal injuries, soft tissue swelling, and nasal, oral, or oropharyngeal bleeding. A low threshold should be maintained for establishing a definitive airway, either by orotracheal or nasotracheal intubation. If intubation is not feasible or attempted and fails, an emergent tracheostomy should be performed.

Another essential consideration in the mandible fracture patient is the possibility of a cervical spine injury. Considering all patients with facial fractures, if an isolated facial fracture is present, the
rate of concomitant cervical spine injury is 5-8%; if 2 or more facial fractures are present, this rate increases to 7-11%. The patient’s cervical spine should therefore be stabilized with a C-collar on presentation until a cervical spine injury has been excluded with imaging and clinical exam.

Once the patient has been stabilized, a thorough history and physical exam are obtained. Unfortunately attempts to obtain this information is often limited by the patient being intubated, unconscious, confused, or intoxicated and by the presence of tubes, wires, cervical collar, and soft tissue swelling. However, if the patient is awake and cooperative, he or she should be questioned about the presence and location of pain, malocclusion, trismus, intraoral bleeding, and loss of sensation, particularly in the mental nerve region. When examining the patient, the general appearance is first assessed and any lacerations, ecchymoses, edema, or areas of distortion are noted. Chin lacerations indicate an upward blow to the mandible and should alert the examiner to the possibility of subcondylar fractures. The entire mandible is palpated for tender areas, mobility, step-offs, and crepitus. This includes palpation of the condylar heads through the external auditory canals, as pain in this region may indicate the presence of a condylar head fracture. Intraoral inspection should be made for intraoral tears, ecchymoses, and bleeding. The occlusion should be checked bilaterally and note made of any deviation of the mandible, premature molar contact, open bite, crossbite, or trismus. The quality of the dentition is noted, as are any fractured teeth or involvement of teeth in fracture lines. If a tooth is missing and its absence appears to be acute, as chest x-ray should be obtained to ensure the tooth has not been aspirated. If the patient is conscious, a full cranial nerve examination is performed, with special focus on cranial nerves V and VII.

While some surgeons prefer panoramic tomography (Panorex) as the sole imaging modality for mandible fractures, a 1 mm fine cut non-contrasted maxillofacial CT has superior sensitivity to Panorex (100% for the CT vs 86% for the Panorex). In the setting of trauma to the face severe enough to cause a mandible fracture, a CT scan is usually obtained to evaluate for other facial fractures as well. The 3-D reconstructions possible with CT imaging are helpful in some instances, especially comminuted fractures, for pre-operative planning. (Please see slides for several examples of CT and Panorex imaging of mandible fractures.)

**Initial Management**\(^1,2,7,8\)

With rare exception, mandible fractures are not surgical emergencies; however, if surgical intervention is needed, it should be undertaken as soon as it is safe to do so. In the interim, the patient is maintained on a soft diet, adequate medication for good pain control, and antibiotics for all open fractures (including fractures involving tooth roots). Penicillins, cephalosporins, and clindamycin are appropriate antibiotic options. In regard to the timing of fracture repair, Champy and others once advocated for repair within 24 hours; this was often not feasible, resulting in many repairs being delayed well beyond 24 hours. In 2011, Barker et al performed a chart review on 83 patients with mandible fractures over a 5 year period at a single institution; the mean time from injury to fixation was 6.7 days and no correlation was found between increased time to repair and the rate of complications (infection, nonunion, or malunion). A trend was found between fewer complications and increasing time to surgical repair.

Numerous studies have shown no benefit to routine use of postoperative antibiotic therapy beyond 24 hours after repair. There is however, evidence to support both preoperative and perioperative antibiotic use. Chole and Yee showed reduced mandible fracture infection rates from 42% to 14% with the use of 1 gram of cefazolin IV just prior to surgery and one additional dose 8 hours later. All open fractures require antibiotic therapy; closed condyle fractures, however, do not.
Prior to routine antibiotic use, pulling a tooth involved in a fracture line was recommended to reduce the incidence of infection. Current recommendations are to remove a tooth in the fracture line if it is carious, if the tooth and/or its root are fractured, or if the presence of the tooth is preventing proper fracture reduction. Removal of the third molar tends to destabilize angle fractures, as these teeth often account for a large portion of this region, and should be avoided if possible.

**Definitive Management**

The definitive management of mandible fractures ranges from soft diet only to closed reduction by maxillomandibular fixation (MMF) to open reduction and internal fixation (ORIF). Soft diet alone can be optimal treatment for some non-displaced ramus and subcondylar fractures; however, there must be no malocclusion for this to be a viable option. Closed reduction can be accomplished by arch bars, eyelet wires, or IMF screws. ORIF can be accomplished with mini plates, larger reconstruction plates, or lag screws.

The general principles of mandible fracture treatment are: 1) restore the patient’s pre-morbid occlusion, 2) repair both skeletal and soft tissue injuries, 3) use lacerations when possible, 4) use mucosal incisions when possible, 5) reduce all fractures, 6) stabilize fractures, and 7) fixate all fractures adequately to allow bone healing.

**Closed Reduction**

The indications for closed reduction include 1) nondisplaced favorable fractures, 2) pediatric fractures, where open reduction is best avoided due to the risk of injuring tooth buds, 3) grossly comminuted fractures, to avoid periosteal stripping of bone fragments, and 4) condyle fractures, except in cases of bilateral condyle fractures, where closed treatment alone can result in loss of mandibular height. Contraindications to closed reduction include compromised pulmonary function, poorly controlled seizures, severe nausea, and psychiatric/neurologic disorders.

Erich arch bars are the standard method for placing a patient in MMF. Twenty-four gauge circumdental wire is used to fasten each bar to the dentition. The lugs must open AWAY from the crowns of the teeth. Once both bars are in place, the patient is placed in maximum intercuspation and MMF wires or elastics are used to firmly secure the arch bars to each other. IMF screws are 2.5 mm self-drilling and self-tapping screws that are placed adjacent (either medial or lateral) to the canine tooth roots. Wire is then passed between the maxillary and mandibular screws and tightened while the patient’s teeth are held in occlusion. This method is an alternative if arch bars cannot be applied or for temporary MMF during ORIF.

**ORIF**

The indications for ORIF include 1) displaced unfavorable angle fractures, 2) complex facial fractures requiring a stable mandibular base, 3) atrophic edentulous mandibles, which often have minimal cancellous bone and poor osteogenesis/healing potential, and 4) some condylar fractures. The absolute indications for ORIF of condyle fractures include displacement into the middle cranial fossa or external auditory canal, inability to obtain adequate occlusion, lateral extracapsular dislocation, and contaminated open joint wounds. For ORIF, an intraoral approach is preferred; it is more direct, leaving no external scars, and has low risk of facial nerve injury; the disadvantage is exposure is more difficult. External approaches provide improved exposure of the posterior body, angle, and ramus, and is often required for severely comminuted fractures; disadvantages include leaving a cervical scar and risk of
injury to branches of the facial nerve. Ultimately, the approach chosen should allow adequate exposure to reduce and immobilize the fracture(s).

There are two overall competing principles, or schools of thought, concerning ORIF of the mandible. The first is Arbeitsgemenschaft fur Osteosynthesefragen (AO) technique, which emphasizes the use of large, load-bearing plates and bicortical screws, and the second is Champy technique, which emphasizes the use of small, load-sharing plates and monocortical screws. In 2012, Bouloux et al published their results of a two year randomized, non-blinded, prospective trial in which patients with mandible fractures were randomized to either an AO (control) treatment arm or a Champy (experimental) treatment arm. Patients with clinic infection, previous treatment, comminuted fractures, condyle fractures, gunshot injuries, or mandible atrophy were excluded. All patients received perioperative antibiotics, follow up was at least 6 weeks, and no MMF was used. The primary outcome was fracture union status at 6 weeks, which was 81% in the AO group and 89% in the Champy group (p =0.95, not significant). Additionally, no significant difference was found between the two groups for rates of infection, need for hardware removal, or need for prolonged antibiotic therapy.

Treatment by Fracture Location

Symphyseal and Parasympyseal Fractures

- Intraoral vestibular approach best
- Arch bars placed and MMF wires secured prior to incision
- Incision is made from canine to canine, leaving at least a 1 cm cuff of tissue from the mucogingival junction for closure
- Dissection carried to bone
- Freer used to dissect below the periosteum to the inferior border of the mandible
- Mental nerves identified and preserved
- Fracture line debrided, reduced, and MMF tightened
- Four hole 2.0 mm system titanium plate secured just below the tooth roots with monocortical screws
- Four to six hole 2.3 to 2.7 mm system titanium plate is shaped to the lower border of the mandible and secured with at least two screws on each side
- MMF wires cut and occlusion checked; if satisfactory, incision is closed.
- If no other fractures require the arch bars, they are also removed prior to closing

Body Fractures

- Intraoral approach best
- Arch bars placed and MMF wires secured prior to incision
- 5 cm incision made in the gingivobuccal sulcus over the fracture, leaving a 1 cm cuff of tissue from the mucogingival junction for closure
- Mucosa only incision made anteriorly; blunt dissection used to identify and dissect out the mental nerve from the labial flap of tissue
- Dissection carried to bone
- Freer used to dissect below the periosteum to the inferior border of the mandible
- Mental nerves identified and preserved
- Fracture line debrided, reduced, and MMF tightened
- Four hole tension band secured between the tooth roots and mental foramen with monocortical screws
• Larger 2.3 to 2.7 mm system titanium plate is shaped to the lower border of the mandible and secured anteriorly through the intraoral incision with 2-3 screws. If needed, a percutaneous drill guide is placed in the cheek to reach the posterior screw holes and 2-3 screws are placed.
• MMF wires cut and occlusion checked; if satisfactory, incision is closed.
• If no other fractures require the arch bars, they are also removed prior to closure of the incision.

**Angle Fractures**

• Non-displaced fractures can be treated with MMF x 6 weeks.

**Intra-oral approach**

• Intra-oral approach is similar to approach for a body fracture, with incision more posterior and extended superiorly over the external oblique ridge.
• Arch bars placed prior to incision, but MMF is performed after dissection.
• Fracture line is exposed and reduced.
• Plating options include two mini plates, a superior mini plate and heavier lower plate, and a 2 mm 8 hole strut plate.
• Percutaneous drill guide is required to drill holes and place the screws.

**External approach**

• 5 cm incision is made 2 to 2.5 cm below the angle of the mandible and extended posterosuperiorly toward the earlobe.
• Deep subcutaneous dissection is performed inferiorly on top of the platysma.
• Platysma is incised inferiorly and dissection is carried down to the posterior belly of the digastric.
• Once the digastric is identified, dissection is carried superiorly to the inferior border of the mandible.
• Periosteum is incised and a freer is used to elevate the periosteum from the bone, exposing the fracture.
• Fracture is debrided and reduced, and the patient is placed in MMF.
• Plating options include two mini plates, a superior mini plate and heavier lower plate, and a 2 mm 8 hole strut plate.
• After plating, MMF is released and occlusion checked; if satisfactory arch bars are removed unless needed for other fractures.
• Intraoral incisions closed with chromic or vicryl suture.
• For external approach, platysma is closed with a running locking vicryl suture, deep dermal interrupted monocryl sutures are placed, and the skin is closed with 5-0 FAST gut or 5-0 nylon/prolene running suture.

**Ramus Fractures**

• Most ramus fractures can be treated with MMF x 6 weeks.
• Intraoral plating is very difficult.
• External approach for plating is similar to that of angle fractures.

**Condyle Fractures**

• Most condyle fractures can be treated with MMF x 2-4 weeks.
• If the head is involved, MMF is limited to 2 weeks to prevent TMJ ankylosis.
Frequent scenario is a condyle fracture with contralateral parasymphyseal, body, or angle fracture—treat contralateral fracture with ORIF and condyle fracture with MMF x 2-4 weeks. When plating is required, an external approach is preferred. External approach is similar to the angle approach but with the superior end of the incision brought to about 2 cm from the earlobe.

**Coronoid Fractures**

- Uncommon, usually associated with a ZMC fracture

*No treatment is required in the majority of cases*

**Postoperative Care**¹⁰,¹¹

Wire cutters are kept at bedside upon leaving the operating room and sent home with the patient. Antibiotics do not need to be routinely continued beyond 24 hours post-op. Oral hygiene is stressed, including daily brushing of the teeth and arch bars; a water pick is also very effective. Dental wax is used to protect the buccal mucosa from the sharp edges of the wires and arch bars, if applicable. The patient is followed every week until the arch bars are removed.

**Complications**¹⁰,¹¹

**Infection**

- Occurs in 10-15% of patients
- No significant decrease in the infection rate with extended post-op antibiotics
- Thought to result from fracture instability and movement instead of contamination with oral flora
- Predisposing factors
  - Local
  - Poor reduction/immobilization
  - Poorly closed oral wounds
  - Fractured teeth in the fracture line
  - Diminished blood supply
  - Devitalized tissue
  - Comminuted fractures
  - Systemic
  - Alcoholism
  - Poorly controlled DM
  - Immunocompromise
- Treatment is surgical drainage, removal of infected hardware, and prolonged antibiotic therapy
- Placement of a heavy reconstruction plate may be required

**Nonunion**

- Occurs in 3-5% of fractures
- Most common cause is inadequate reduction and immobilization
- Treatment
  - Control infection if present
  - Debride devitalized tissues
  - Remove hardware, freshen fracture ends, and place a new heavy plate
  - Place bone graft if needed
Malunion

- Improper alignment of the healed bony segments
- Caused by improper reduction, inadequate occlusal alignment, and inadequate stability of the fracture
- May be clinically insignificant if occlusion is good

Treatment

- Minor discrepancies can be treated with orthodontics
- Major discrepancies require open surgical repair with refracturing and/or osteotomies

TMJ Ankylosis

- Mandibular condyle fuses to the glenoid fossa
- Predisposing factors
  - Intra-articular hemorrhage
  - Condyle head fracture
- Prevention
  - Shorter period of MMF (2-3 weeks)
  - Physiotherapy
  - Definitive treatment may require arthroplasty or total joint replacement

Trigeminal Nerve Injury

- Inferior alveolar nerve frequently injured when fracture involves the mandibular canal
- Mental nerve at iatrogenic risk especially during parasymphyseal and body fracture repairs
- Important to document deficits prior to surgery

Facial Nerve Injury

- In a trauma patient, the nerve can be injured anywhere along its course
- Main trunk can be injured from fractures or surgery around the condylar neck
- Marginal mandibular branch at risk during submandibular external approaches
- Frontal branch at risk if an external pre-auricular approach is used
- Facial nerve function should be documented prior to surgery

References

9. Bouloux GF, Chen S, Threadgill JM. Small and large titanium plates are equally effective for treating mandible fractures. *J Oral and Maxillofac Surg* 2012;70:1613-21