Patients with mandibular fractures can present with many different fracture patterns which need to be treated on a case by case basis. To accurately treat fractures of the mandible, the surgeon must first understand the anatomy and physiology surrounding the mandible. The mandible interfaces with the skull base via the temporomandibular joint and is held in position by the muscles of mastication. The bone of the mandible can be divided into the following components: coronoid, condyle, ramus, angle, body, parasymphysis, symphysis and alveolus. The weakest sites are the third molar area, socket of the canine tooth, and the condyle. The arterial supply of the mandible is from the internal maxillary artery from the external carotid with contributions to the inferior alveolar artery through the mandibular foramen and the mental artery through the mental foramen. Innervation of the mandible is from the mandibular nerve through the foramen ovale with contributions to the inferior alveolar nerve through the mandibular foramen, inferior dental plexus and the mental nerve through the mental foramen.

Dental occlusion can be classified as normal(Class I), overbite(Class II), or underbite(Class III). This is based on the relationship of the mesiobuccal cusp of the maxillary first molar to the buccal groove of the mandibular first molar. The universal numbering system for permanent teeth begins with the right third molar of the maxilla to the left third molar of the maxilla(number 16) and then goes to the left third molar of the mandible(number 17) to the right third molar of the mandible(number 32). The 20 deciduous teeth are lettered in a similar fashion from A to T. Mandible fractures occur most commonly in young male adults(mean age of 23). Fractures can be single or multiple. Mandible fractures can also be classified by the presence or absence of teeth. Class I fractures have teeth on both sides of the fracture line. Class II fractures have teeth on only one side of the fracture and Class III fractures occur in completely edentulous patients. The most common site to be fractured is the condyle of the mandible(36%). The body(21%) and angle(20%) are second and third in frequency respectively.
The forces acting on the mandible are an important consideration in mandible fractures. The lateral pterygoid protrudes the jaw and arises from the lateral pterygoid plate and inserts on the condylar neck and the temporomandibular joint capsule. The mylohyoid, digastric, genioglossus, and the geniohyoid all depress and retract the jaw. The mylohyoid arises from the mylohyoid line and inserts into the body of the hyoid. The digastric arises at the mastoid notch and inserts into the digastric fossa. The genioglossus arises from the genial tubercle and fans out to the entire length of the inferior surface of the tongue. The geniohyoid arises from the inferior genial tubercle and inserts into the anterior hyoid bone. The elevators of the jaw include the temporalis, masseter, and medial pterygoid. Inward displacement of the jaw results from the actions of the lateral and medial pterygoid muscles. The masseter arises from the zygoma and inserts into the angle and the ramus. The temporalis arises from the infratemporal fossa and inserts on the coronoid process and ramus. The medial pterygoid arises from the medial pterygoid plate and the pyramidal process of the palatine bone and inserts on the inner table of the lower mandible.

Favorable fractures are those fractures where muscles tend to draw the fragments together. Ramus fractures are almost always favorable secondary to the elevating forces of the muscles. Unfavorable fractures result when the muscles tend to draw the fragments apart. Most angle fractures are horizontally unfavorable because of the pull of the jaw elevators. Vertically unfavorable fractures of the symphysis and parasymphysis tend to collapse inward in a scissor-like fashion secondary to the jaw depressors especially the mylohyoid.

When evaluating mandible fractures, it is important to obtain a good history and physical exam. The mechanism of injury can help the clinician anticipate the fracture type. Motor vehicle accidents are associated with multiple comminuted fractures. A fist often results in a single, non-displaced fracture. An anterior blow to the chin results in bilateral condylar fractures. An angled blow to the parasymphysis can lead to contralateral condylar or angle fractures. Clenched teeth can lead to alveolar process fractures. Any history of bone disease, neoplasia, arthritis, temporomandibular joint disease is important. Collagen vascular disease or endocrine disorders, nutritional and metabolic disorders including alcohol abuse can affect patient outcome. A patient with a history of seizure disorder should not be put into maxillomandibular fixation. The physical examination as with any trauma patient begins with evaluation of the patient's ABC's. The pre-injury occlusion is important to assess. Posterior premature dental contact or anterior open bite is suggestive of bilateral condylar or angle fractures. A posterior open bite is common with anterior alveolar process or parasymphysyal fractures. A unilateral open bite is suggestive of a ipsilateral angle and parasymphysyal fracture. Retrognathic occlusion is seen with condylar or angle fractures. Condylar neck fractures are associated with an open bite on the opposite side of the fracture and deviation of the chin towards the side of the fracture. Bilateral mandible fractures of the body can result in airway distress. The physician may need to pull the jaw forward or tongue forward or put the patient in a lateral decubitus position. A tracheotomy may be necessary. Anesthesia of the lower lip is pathognomonic of a fracture distal to the mandibular foramen. Any intraoral or skin lacerations associated with an open fracture can potentially be
used to access the fracture for reduction and fixation. Ecchymosis of the floor of mouth is suspicious for a body or symphyseal fracture. The examination should also assess abnormal mandibular movement. Inability to open the mandible can be due to a coronoid fracture. Inability to close the mandible can be due to a fracture of the alveolus, angle or ramus. Trismus is usually the result of splinting by the patient due to pain. Multiple fractures of the teeth are associated with alveolar fractures. The mandible should also be palpated for point tenderness and crepitus.

Radiographic evaluation begins with evaluation of the cervical spine for injury. At least, a lateral cspine film is necessary with the addition of an odontoid and AP view based on clinical suspicion. The panorex is the single best mandibular film to get. It shows the entire mandible but the patient has to be upright with a cleared spine. This can be difficult for the patient with multisystem trauma. In addition, the panorex gives poor detail in the temporomandibular joint area and does not show medial condylar displacement and alveolar process fractures. Plain films of the mandible include the AP, lateral, reverse Townes and submental views. The AP view shows the ramus and condyle well. The submental view is good for evaluating the symphysis.

Forty to sixty percent of mandible fractures are associated with other injuries. Ten percent of these are lethal. The most common associated injury is to the chest. Cervical spine injury is associated in 2.59% of mandible fractures. Although the incidence of cervical spine injury associated with mandible fractures is low, missing this injury could result in severe neurological sequelae. Motor vehicle accidents are the predominant cause of cervical spine injury in association with mandible fractures. C1 and C2 are most commonly involved. Condylar fractures can rarely be displaced with the fragment herniating through the roof of the glenoid fossa into the floor of the middle cranial fossa which can be associated with a dural tear. If this happens, consultation to neurosurgery should be obtained.

Treatment of mandible fractures includes a tetanus booster as indicated by immunization records. Almost all fractures can be considered open as they usually communicate either with the skin or oral cavity. Correction of pre-existing nutritional deficiencies is important in the healing phase. Although not an emergency, reduction and fixation should be undertaken as expeditiously as possible as this usually helps with pain management and fractures may be easier to reduce. It is interesting to note that delayed fixation of mandible fractures has not been shown to increase the infection rate. Common pathogens involved in mandible fracture associated infection include strept, staph and bacteroides. Therefore, the patient is routinely placed on clindamycin or penicillin. Oral care should be instituted with half strength hydrogen peroxide rinses. Once hardware is placed, a bi-weekly exam is usually sufficient in the adult patient to assess the status of the hardware, and the patient's occlusion and nutritional status.

Treatment options of mandible fractures include no treatment for isolated nondisplaced fractures of the coronoid process. These fractures need to be reduced when the fracture fragment is impinging on the zygoma and the patient is unable to open his mouth. A soft or liquid diet and
pain control may be the only treatment necessary for a unilateral nondisplaced fracture of the subcondylar area with normal occlusion. If the patient develops malocclusion and/or persistent pain, he needs to be managed with mandibulomaxillary fixation (MMF). Classical indications for closed reduction (MMF) include grossly comminuted fractures which heal better with the periosteum intact. A fracture with significant loss of soft tissue or a fracture in an edentulous patient are also indications for treatment with MMF. Open reduction can lead to damage of the developing teeth in children. A condylar fracture treated with open reduction can lead to damage of the temporomandibular joint. These fractures are also classically treated with MMF. MMF is contraindicated in epileptics, alcoholics, psychiatric and frail patients who can not tolerate jaw wired shut.

MMF involves placement of arch bars onto the gingiva of the maxilla and mandible. These bars are fixed into place with 24 gauge wire to the interdental spaces of the premolar and molars. Care is taken not to put wires around the incisors as these can be avulsed or moved by placement of wires. Once the arch bars are secure, and the fracture reduced with the patient in normal occlusion, fish loops are placed to wire the mandible to the maxilla. Ivy loops made out of 26 gauge wire are used in selectively bringing occlusal pairs of teeth together. They have an application in children with mixed dentition, in partially edentulous patients who will have additional forms of fixation, and in patients who need temporary occlusion while other methods are being applied such as plates or external fixation. To make ivy loops, 26 gauge wire is cut to a 16 cm length and a small loop is formed in the center of the wire around a hemostat. The ends are inserted between two suitable teeth and the mesial end is passed through the loop and then tightened. 28 gauge wire goes through the eyelets for fixation.

Classical indications for open reduction include malocclusion despite MMF, a displaced unfavorable fracture through the angle, body or parasymphysis, and multiple fractures of the facial bones. In the case of associated midface fractures, the mandible is fixed first providing a stable base for restoration. Malunion after closed reduction is treated with osteotomies and ORIF. Open reduction with non-rigid fixation is more forgiving and easier to place. It still requires MMF and is useful in angle and parasymphysial fractures. Non-rigid fixation can be performed with simple wires, figure - of - eight wires or high wires. These can be placed extrorally or transorally (e.g. with the high wire). Arch bars are always placed first to establish occlusion, then ORIF is performed. The plates can be place intraorally, extraorally via a cervical incision or percutaneously.

Dynamic compression plates (DCP) can be used for most of the body, angle, symphyseal or parasymphysial fractures. To put in a DCP, one first fits a 4 hole plate to the site of the fracture with 2 holes on either side of fracture. The DCP is secured by drilling a hole at the outer edge of the inner eccentric compression hole. This is repeated on the other side. These holes are drilled with a 2.1 mm drill bit and 2.7 mm screws are placed so that compression is obtained. Next, the other two lateral drill holes are drilled and screws placed in a normal fashion. The disadvantages include traumatic bone loss, extensive comminution, and severe bone atrophy. A lag screw can
also be used to compress bone fragments on either side of the fracture line. This technique is useful for the oblique horizontally directed angle fracture or for parasymphysal fractures. Only surgeons experienced in ORIF should use this technique as there is the potential for disabilitating malunion if plates are not placed exactly. To perform lag screw insertion, first the outer segment of bone is drilled with a 2.7 mm drill bit. Once the inner cortex is reached, drilling is ceased and a 2 mm drill bit is placed through the inner cortex. Next, a screw slightly larger than 2mm is inserted. Tightening this screw forces the outer fragment against the head and the deep fragment in then brought up into contact with the outer fragment. Those fractures that have a straight course from the buccal to the lingual cortex lend themselves more to use of a DCP. Fractures that are oblique or sagittal are better suited for lag screws. Use of compression hardware in cases of infection or comminution is not recommended. For these cases, large reconstruction plates (e.g. 2.4mm) is the treatment of choice. External fixation is usually necessary in comminuted fractures such as gun shot wound injuries. Fractured teeth can become infected and cause malunion. Extraction is necessary if the root of the tooth is fractured. A tooth that is intact but in the line of the fracture can be left in place and protected by antibiotics but may need attention from a dentist at a later date.

Condylar fractures most often are treated with MMF only. If nondisplaced, this is left in place for 3 weeks followed by elastics for 2 weeks. If displaced, the patient will need 6 weeks of MMF. Absolute indications for ORIF of condylar fractures include displacement of the fragment into the middle cranial fossa, lack of adequate reduction with MMF, lateral extracapsular displacement of the condyle, and invasion by a foreign body (e.g. a GSW). Relative indications for ORIF of condylar fractures include bilateral condylar fractures in an edentulous patient when splinting is impossible, unilateral or bilateral condylar fractures when splinting is not recommended for medical reasons, bilateral condylar fractures associated with midface fractures, and bilateral condylar fractures with significant pre-injury malocclusion. To avoid ankylosing the TMJ, mobilization needs to be performed every 2 weeks in adult patients and weekly in children. Ramus fractures are usually favorable and can be treated with MMF. Angle fractures are treated with MMF only if favorable. If unfavorable, they need ORIF. Body fractures are treated in a similar manner to angle fractures. Symphyseal or parasymphysal fractures usually require ORIF and lag screws or compression plates can be used.

Special considerations need to be taken into account when dealing with mandible fractures in a pediatric or edentulous patient. Fractures with deciduous dentition can be treated with MMF for 2-3 weeks. Open rigid techniques may harm the tooth bud. The most feared complication of a pediatric mandible fracture is ankylosing of the TMJ with impact on mandibular growth centers that causes severe facial deformity. This can be prevented with early weekly mobilization. It is harder to place peridontal wire ligatures around deciduous teeth because the tooth is closer to the gingival margin than the crown of the permanent tooth so it may be necessary to secure the wires to the piriform rim and mandible by circummandibular wires. Edentulous patients may undergo closed reduction by wiring the patient's dentures to his jaws using circummandibular and circumzygomatic wires. Screws can also be placed to fixate the dentures into the palate or
mandible. If no dentures are available, Gunning splints with an arch bar incorporated into them can be used for closed reduction. To make the splints, an impression is first made. Next, a cast made out of plaster or stone is made from the impression. Then acrylic splints are made with holes for wiring and grooves for circummandibular and circumzygomatic fixation.

Socioeconomic condition greatly affects outcome of mandible fractures as patients tend to be more compliant with their medical care. The infection rate of mandible fractures is 7% as quoted in a prospective study by James. Fifty percent of these were associated with fractured or carious teeth. Delayed healing (3%) nonunion (1%) is most commonly caused by infection. The next most common cause is non-compliance. Inadequate reduction and metabolic or nutritional deficiencies can play a role. Nerve paresthesia's of the inferior alveolar nerve can occur in 2% of the patient's in James' study. Malocclusion and malunion, and TMJ syndrome can also occur after treatment of mandible fractures. A study out of UCSF showed no statistical significant difference in the complication rate between patient's treated with miniplates versus MMF and wire fixation. Another study based on a group of patient's with angle fractures all treated at Parkland hospital in Dallas with either nonrigid fixation or an AO reconstruction plate or a lag screw or 2 - 2.0 mm DCP's or 2 - 2.4 mm DCP's or 2 - 2.0 mm miniplates or one 2.0 miniplate showed the lowest complication rate to be with the one 2.0 miniplate with an arch bar as a tension band. The complications studied included: malunion, nonunion, facial nerve palsy, infection, and pain.

With multiple techniques available, there is still controversy over the best treatment for each type of mandible fracture. The decision is a clinical one based on patient factors, the type of mandible fracture, the type of hardware available and the skill of the surgeon. Existing studies are controversial. Further prospective studies need to be completed.

References
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