Evidence-Based Medicine: Mandible Fractures

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Learning Objectives: After reading this article, the participant should be able to: 1. Explain the epidemiology of mandible fractures. 2. Discuss preoperative evaluation of the patient with a mandible fracture. 3. Compare the various modalities of fracture fixation. 4. Identify common complications after fracture repair.

Summary: In this Maintenance of Certification/Continuing Medical Education article, the reader is provided with a review of the epidemiology, preoperative evaluation, perioperative management, and surgical outcomes of mandible fractures. The objective of this series is to present a review of the literature so that the practicing physician can remain up-to-date on key evidence-based guidelines to enhance management and improve outcomes. The physician can also seek further in-depth study of the topic through the references provided. (*Plast. Reconstr. Surg.* 140: 192e, 2017.)

Mandible fractures are frequently encountered by plastic surgeons and represent one of the most common facial injuries. The single greatest factor in the evolving epidemiology of facial trauma has been the pervasive installment of modernized airbag and safety technology in passenger vehicles.[1] The incidence and severity of panfacial injuries has since dropped dramatically.[2] Concurrently, rates of violent crime (e.g., simple assault) have recently risen in the United States.[3] As such, interpersonal violence is the cause of the majority of adult mandible fractures in Western countries, most often in men aged 25 to 34 years (**Reference 5, Level of Evidence: Therapeutic, IV**).[4–6] Moreover, it is increasingly common for patients to present with isolated mandible fractures. In one study by Haug et al.,[4] the authors reported a ratio of mandible to zygomatic fractures of 3:1. In this same study,[4] it was found that assaults and motor vehicle collisions significantly outweighed all other causes of mandibular injury by a factor of 10.

Preoperative Imaging

Most patients with mandible fractures present to an emergency room and undergo initial computed tomographic scanning to evaluate their facial injuries. Therefore, most consultations for mandible fractures begin with a computed tomographic imaging diagnosis. Increasingly, panoramic tomograms (Panorex; Digital Imaging Technologies Corp., Hatfield, Pa.) are hard to find in emergency rooms, and the question of the necessity of these radiographs is often debated. In one study by Wilson et al.,[7] a group of fractures with both computed tomographic and panoramic radiographic data was evaluated (**Level of Evidence: Diagnostic, II**). Not surprisingly, the study found that computed tomographic scans were 100 percent sensitive for mandible fractures compared with 86 percent for panoramic radiographs. That is to say, no mandible fractures were missed with computed tomography. However, computed tomographic scans provide very little useful concomitant information about dental trauma. This is particularly important in the context of the third molar and its involvement in mandibular angle fractures. Consequently, it is not unreasonable to accept the computed tomographic scan as the only radiographic modality in the diagnosis of a mandible fracture with the exception of injuries to the angle. If there is a question of the integrity or condition of the third molar or any other tooth, additional imaging such as a pantomogram

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should be obtained.[7,8] Alternatively, if the appropriate software program is available, manipulation of Digital Imaging and Communications in Medicine data in three dimensions can allow the surgeon to effectively visualize the computed tomographic image in panoramic view.

Preoperative Evaluation

Radiographic images do not substitute for a thorough history and clinical examination. Ascertaining the mechanism of injury can provide valuable information, as interpersonal altercations tend to result in a higher incidence of angle fractures, whereas motor vehicle collisions are more commonly associated with parasymphyseal fractures (**Level of Evidence: Therapeutic, IV**).[5] Concomitant injuries must be ruled out during primary and secondary trauma surveys, especially after motor vehicle accidents, and careful evaluation of the cervical spine is required before proceeding with any operative management.[9–13] The patient should be questioned regarding a history of orthodontic or dental treatment and any problems with the temporomandibular joint.

Certainly, the most important component of the clinical examination is assessment of the occlusion. One must remember that a patient's occlusion is not "good" or "bad." The only question is whether or not the patient has maintained his or her preinjury occlusion, which is often imperfect in many individuals. Patients are typically very good at relating whether or not their occlusion is at baseline. As such, a subjective report of malocclusion by a patient should be taken seriously. In evaluating this visually, the examiner should place gloved fingers within the mouth on either cheek of a cooperative patient and retract them outward while asking the patient to bite down. The wear facets of the teeth should be assessed for contact. Many patients, when asked to bite down for this portion of the examination, will have a tendency to protrude the mandible. It is important to have the patient relax and allow the condyles to seat firmly in the joint. It may be helpful to instruct the patient to touch the tongue to the roof of the mouth, as this tends to correct the protruded position. The area of the suspected fracture should also be palpated bimanually to check for mobility at the fracture site. Lack of mobility is an indicator of a stable fracture that may be amenable to conservative management, provided that the occlusion has not been altered.

The status of the dentition should also be evaluated. Seriously carious or damaged teeth, particularly at the site of the fracture, should prompt consideration for extraction to facilitate fracture healing. According to Chidyllo and Marschall,[14] tooth extraction is recommended if a comminuted or displaced fracture contains a tooth, if the tooth root is fractured, if there is periodontal disease or an abscess near the fracture line, or if the tooth is functionless because of lack of opposing teeth. Lacerations or hematomas at the fracture site are also important to note as these may lead to an increased risk of infection, complicating treatment.

Sensation in the lower lip should also be tested. Damage to the inferior alveolar nerve as it courses through the body of the mandible is not uncommon with these injuries. Failure to note this preoperatively may be mistaken as a postoperative complication. Finally, function of the marginal mandibular nerve branch in depressing the lower lip should be assessed and documented. Although this is rarely a preoperative finding, it is sometimes weak postoperatively following procedures that reduce and stabilize mandibular fractures.

ANTIBIOTIC PROPHYLAXIS

Although antibiotics are frequently given postoperatively after open reduction and internal fixation of mandible fractures, there is no evidence that this confers any benefit. In a randomized, double-blind, placebo-controlled study by Abubaker and Rollert in 2001, there was no statistically significant difference in the incidence of postoperative infection between the group receiving oral penicillin postoperatively compared to the placebo-controlled group (**Level of Evidence: Therapeutic, I**).[15] A similar prospective trial by Miles et al. in 2006 also failed to demonstrate any benefit to postoperative antibiotics in patients undergoing open reduction and internal fixation of mandible fractures (**Level of Evidence: Therapeutic, I**).[16]

There is ample evidence, however, that preoperative administration of antibiotics is beneficial. Numerous studies have shown that administrating antibiotics before the operative procedure reduces the rate of postoperative infection in mandible fractures.[17–19] Certainly, those patients presenting with open fractures (i.e., through tooth-bearing regions) should receive antibiotics as soon as possible after diagnosis. Commonly used antibiotics include penicillin, cefazolin, metronidazole, and clindamycin. It should also be mentioned that smokers and patients with systemic medical conditions appear to have an increased incidence of complications, including infection (**Level of Evidence: Therapeutic, IV**).[20]

SURGICAL MANAGEMENT

The majority of mandible fractures will require stabilization for adequate healing and to restore preinjury occlusion. In situations where one encounters a nondisplaced fracture with no evidence of mobility by manual palpation, a soft diet for 4 to 6 weeks may be adequate treatment. For displaced fractures and those demonstrating mobility on clinical examination, some form of immobilization is typically required. (**See Video, Supplemental Digital Content 1**, which displays operative setup and assessment of the occlusion, available in the "Related Videos" section of the full-text article on PRSJournal.com or at ***http://links.lww.com/PRS/C226***.) Although mandible fractures with good dentition on either side of the fracture line may be treated in some cases by a period of intermaxillary fixation, most surgeons and patients would prefer open reduction and internal fixation, as this allows a much more rapid return to full preinjury function and mobility. The patient's demographics, comorbidities, dentition, and fracture characterization will all influence the choice of fixation by the treating surgeon.[21]

Fixation

When discussing fundamentals of fixation, particularly in how they apply to the treatment of mandible fractures, one must comment on just how much influence the works and teachings of Ed Ellis have had. In the field of mandibular trauma, no other surgeon is his equal in terms of experience and authority. Most of what follows comes from the enormous body of scientific work he has produced.

Internal fixation for mandible fractures can be divided into two categories: load-bearing and load-sharing.[8,22,23] Load-bearing fixation denotes a construct that is capable of bearing all of the load generated by mandibular function such that the host bone at the fracture site shares none of the functional load.[8] Typically, this requires the application of a large reconstructive plate to the inferior border of the mandible (Fig. 1, *left*). This is required when there is insufficient bone at the fracture site to bear any load. Examples of load-bearing fixation include defect fractures, comminuted fractures, and fractures in severely atrophic mandibles.[23] In contrast, load-sharing fixation characterizes a fixation scheme whereby the functional load is shared between the fixation hardware and the bone along the fracture site.[8] Load-sharing fixation can further be divided into rigid and nonrigid (functionally stable) fixation. The cardinal difference between rigid and nonrigid fixation centers on interfragmentary mobility.[24] Nonrigid fixation allows some motion (micromotion) at the fracture site, but provides sufficient stability to allow bone healing with callous formation.[8] Examples include a single miniplate along the oblique ridge (Fig. 1, *center*) of the mandible for angle fractures or a single miniplate and an arch bar for body or symphyseal fractures.[22] By comparison, rigid fixation restricts micromotion and allows primary bone healing without callus formation. Examples include two miniplates (Fig. 1, *right*), multiple lag screws, or certainly a reconstruction plate (Fig. 1, *left*).[22] Load-sharing fixation is typically appropriate only for isolated simple fractures with good bone-to-bone contact at the fracture line. All other fractures (multiple fractures, infected fractures, and fractures with poor bone-to-bone contact) require rigid fixation.

Video 1. Supplemental Digital Content 1, which displays operative setup and assessment of the occlusion, is available in the "Related Videos" section of the full-text article on PRSJournal.com or at ***http://links.lww.com/PRS/C226***.

In the past, surgeons often referred to plates by the size of the outer diameter of the screw used in the plate (e.g., 2.0-mm plate, 2.4-mm plate). Current plating systems are somewhat more complex than this. Increasingly, these systems have a variety of plate thicknesses that accommodate screws from 2 to 2.7 mm in diameter. That is, all screws are compatible with all plates in the set. Typically, when one refers to rigid fixation in such a setting, it is implied that a thick plate and larger screws are used. Plate thicknesses vary in some sets from 1 mm in profile to 2.8 mm in profile. Clearly, a 2.8-mm-profile plate using a 2.7-mm screw would accomplish rigid fixation if performed properly. At the other end of the spectrum, a 1-mm profile plate with a 2-mm screw would achieve nonrigid fixation. Everything in between is a shade of gray depending on the number and location of plates used.

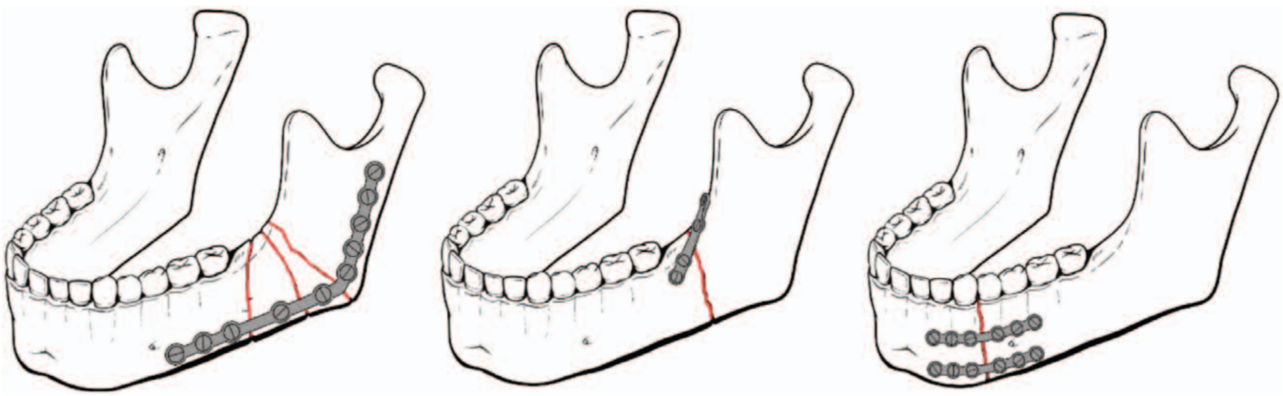


Fig. 1. (*Left*) Mandibular body fracture with two miniplates for rigid fixation. (*Center*) Angle fracture with single miniplate along the oblique ridge. (*Right*) Comminuted fracture with reconstruction plate along the inferior mandibular border for load-bearing fixation. (Printed with permission Texas Children's Hospital.)

Functionally, from the standpoint of the surgeon, differences exist in the ease of adaptability of the plate to the mandibular contours. The larger, thicker plates are much more difficult to adapt to the irregularities of the outer cortex of the mandible, increasing the possibility of malocclusion from a poorly adapted plate. This is less common with smaller plates or miniplates. It is exactly this issue that has led to the development of locking plates (Fig. 2). That is, the holes within these plates have threads. Likewise, the head of the screw is threaded to allow the head to screw into the plate itself. As the screw is being turned, this interaction prevents the plate-screw construct from pulling the bone up to the plate if it is not sitting flush. In theory, a locking plate should prevent malocclusion resulting from a poorly adapted plate. In most sets, there are threaded and nonthreaded screws available, depending on the situation and the surgeon's preference.

FRACTURE LOCATIONS

Body

Fractures of the mandibular body can sometimes be treated closed with a period of maxillomandibular fixation, particularly when the patient has good dentition allowing for stable arch bar application. However, this practice results in a prolonged period of immobility and challenges with intraoral hygiene. As such, patients may prefer open reduction and internal fixation to avoid the discomfort and hindrance of dental wiring. This is commonly accomplished by using a single large plate along the inferior border or by two smaller plates (Fig. 1, *right*), one on the inferior border and another placed just below the tooth roots above this (**Level of Evidence: Therapeutic, III**).[25] (**See Video, Supplemental Digital Content 2**, which displays maxillomandibular fixation and plating of an anterior mandibular body fracture, available in the "Related Videos" section of the full-text article on PRSJournal.com or at ***http://links.lww.com/PRS/C227***.)

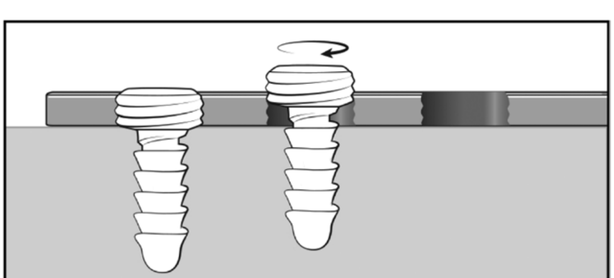


Fig. 2. Locking plate with threads present within the holes. (Printed with permission Texas Children's Hospital.)

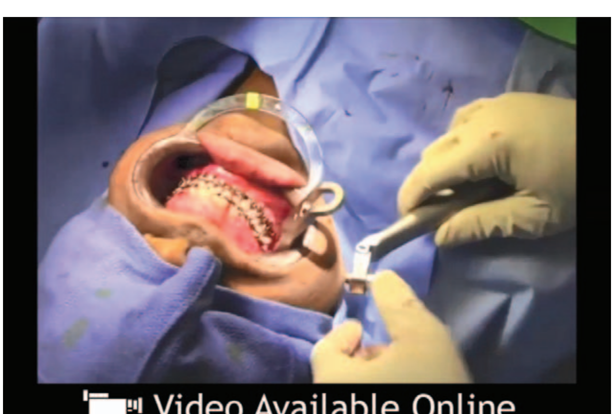
Symphysis/Parasymphysis

This is a challenging area of the mandible, given the acute curvature. Adapting thicker reconstruction-type plates requires greater attention to detail to prevent maladaptation and subsequent malocclusion. Two miniplates are sufficient in most situations and result in similar outcomes but with more postoperative complications.[25] By the same token, there have been advocates for lag screws in this region. Two lag screws provide rigid fixation with relatively low treatment costs.[26] However, this procedure is very technique sensitive.[27] These long screws are difficult to apply correctly and can result in sheering of the fracture fragments and subsequent malocclusion if good bone-to-bone contact is not present. The mental nerve is also a challenge in this area and the surgeon must use great caution when manipulating the plate and drilling the bone to avoid injury.

Video 2. Supplemental Digital Content 2, which displays maxillomandibular fixation and plating of an anterior mandibular body fracture, IS available in the "Related Videos" section of the full-text article on PRSJournal.com or at ***http://links.lww.com/PRS/C227***.

Angle

Mandibular angle fractures are some of the most technically challenging for the reconstructive surgeon and are associated with the highest complication rate of all mandible fractures.[19,28,29] (**See Video, Supplemental Digital Content 3**, which displays plating of a mandibular angle fracture, available in the "Related Videos" section of the full-text article on PRSJournal.com or at ***http://links.lww.com/PRS/C228***.) Common strategies to stabilize these fractures have included a single plate along the oblique ridge, two lateral border plates, or a matrix-type miniplate on the lateral border. Ed Ellis performed a landmark study in 2010 where he looked at a series of 185 patients over a 12-year period treated in one of three ways (**Level of Evidence: Therapeutic, II**).[28]



Video 3. Supplemental Digital Content 3, which displays plating of a mandibular angle fracture, is available in the "Related Videos" section of the full-text article on PRSJournal.com or at ***http://links.lww.com/PRS/C228***.

These included 5 to 6 weeks of maxillomandibular fixation, a single miniplate, and two miniplates. The first two of these methods result in nonrigid fixation, with the third method producing rigid fixation. Ellis found that the single-miniplate approach was associated with the lowest number of complications and was the easiest operation to perform (**Level of Evidence: Therapeutic, II**).[28] The reasons for these findings are not entirely clear and are incongruous with traditional principles of rigid internal fixation.[24] One might anticipate that the more rigid construct achieved by two plates along the lateral border of the mandible would result in the best outcome through prevention of fragment mobility. However, this was not the case and highlights the notion that clinical results do not always corroborate the results of biomechanical studies.[24]

Condyle

Condylar fractures are regarded as some of the most controversial in terms of treatment. First, we must distinguish between fractures of the condyle itself and fractures of the condylar neck. Fractures of the head of the condyle are relatively uncommon in adults (they predominate in young children) and are typically treated in closed fashion, as the fragments are small, and its location within the temporomandibular joint places the patient at high risk for ankylosis. As such, these patients require early range-of-motion exercises. Fractures of the condylar neck are more common and result in more serious occlusion disturbances. The majority of these result from indirect forces directed to this weak part of the mandible from a blow elsewhere (e.g., the chin).[30] For years, the standard therapy was to place the patient in maxillomandibular fixation for a period of 4 to 6 weeks. Increasingly, closed treatment, as it has been called, has evolved into the use of the maxillary mandibular arch bar with intermaxillary elastics, allowing the patient to open and close the jaw, in essence training the patient to achieve their preinjury occlusion. However, many surgeons feel that some of these patients benefit more from open reduction and internal fixation. Proponents of this latter technique argue that patients treated appropriately by internal fixation have superior outcomes, particularly when one evaluates problems such as deviation of the jaw with maximal opening and temporomandibular joint pain. One meta-analysis published by Kyzas and colleagues in 2012 argues that although this may be the case, the available evidence evaluated is not of good quality and certainly not sufficient to mandate a change in practice (**Level of Evidence: Therapeutic, I**).[30] Ellis et al. feel that the vast majority of unilateral subcondylar fractures with good dentition that can be followed closely can be treated in closed fashion.[31] The situation is not as clear for bilateral fractures.[31] As they describe in their 2012 article in *Facial Plastic Surgery Clinics of North America*, "Bilateral loss of vertical and horizontal support from disruption of the craniomandibular articulation means that the mandible is essentially a free-floating bone, positioned only by the muscles and ligaments attached to it, and the dentition."[31–34] Although only a relatively small percentage of these patients develop a malocclusion that later requires orthognathic surgery to treat, it is difficult to predict which patients these will be.[31] Treating at least one of these fractures by open reduction and internal fixation, Ellis et al. feel, may be the best form of treatment. The indications for open treatment become even clearer in the case of a bilateral subcondylar fracture associated with unstable maxillary fractures. In a situation like this, without stabilizing the condylar region, there is no vertical framework of reference for facial height.

ATROPHIC MANDIBLE FRACTURES

Atrophic fractures are generally categorized as those with less than 15 mm of bone height at the fracture site.[35] An atrophic mandible is more vulnerable to fracture because of the decreased bone volume. These patients are also at particularly high risk for nonhealing by virtue of the tenuous blood supply and poor bone stock of the atrophic mandible. Numerous studies have been performed demonstrating a relatively high rate of nonunion when anything less than rigid fixation is used. Other controversies include the approach to the bone, whether it ought to be subperiosteal or supraperiosteal. Traditionally, fractures of the mandible are exposed in a subperiosteal plane to facilitate reduction and the application of fixation devices directly to the bone.[35] Some have felt that remaining above the periosteum better preserves blood supply.[36,37] There is no good evidence for this, however, and this approach is certainly more difficult than the subperiosteal approach in allowing visualization of the fracture site and application of the hardware. As such, the potential for malreduction increases. Ellis and Price contend that the supraperiosteal approach is unproven and is probably unwarranted.[35]

Yet another controversy in this area is whether or not to use bone grafts immediately. The addition of bone during the initial repair of fractures in the atrophic mandible is a reasonable consideration, as the atrophic mandible has poor blood supply with poor healing ability.[35] However, this adds an additional procedure, with harvest typically from the hip in elderly and sometimes debilitated patients. In his 2008 article on treatment protocols for atrophic mandible fractures, Ellis and Price recommend the use of 2.0-mm locking plates with a subperiosteal extraoral approach using immediate bone grafts in the most atrophic situations.[35] Indeed, using the 2.0-mm bone plate in atrophic mandibular fractures has several advantages. Because this plate is thinner, there is less likelihood that it will become palpable or exposed through the soft tissues. In addition, the 2.0-mm plate is much easier to adapt than the thicker 2.4-mm reconstruction plate. The lower height of the plate also decreases the risk of interference with dentures.[35]

PEDIATRIC FRACTURES

The mandible is the site of injury in approximately 40 percent of pediatric facial fractures, most frequently as a result of motor vehicle accidents and falls.[38–41] The most common mandible fractures in children involve the condyle, accounting for 40 to 70 percent of mandible fractures.[42,43] At a young age, the condylar head is a very vascular mass covered by a cartilaginous cap. Forces transmitted to this region often result in an intraarticular fracture. The clinical presentation of these patients can be very deceptive, where the chief complaint is simply a chin laceration and jaw pain. As children are often not terribly reliable in cooperation with the history and examination, it is easy to overlook the fracture and any associated injuries. One must maintain a low threshold for obtaining imaging studies if warranted by the mechanism of injury.

A key element that distinguishes the pediatric mandible fracture is the dentition. As such, the developmental status of the child should be considered when managing these fractures. From approximately 6 months to 2 years of age, the deciduous (primary) dentition erupts. This results in 20 primary teeth that, beginning at approximately 6 years of age, begin to fall out as the roots are resorbed. From age 6 to 12 years, the secondary (permanent) dentition erupts. Until the mixed dentition phase is complete, the bone of the mandible in the regions of the parasymphyseal and body is occupied by the developing tooth buds (Fig. 3, *left*).[44] This strongly influences where

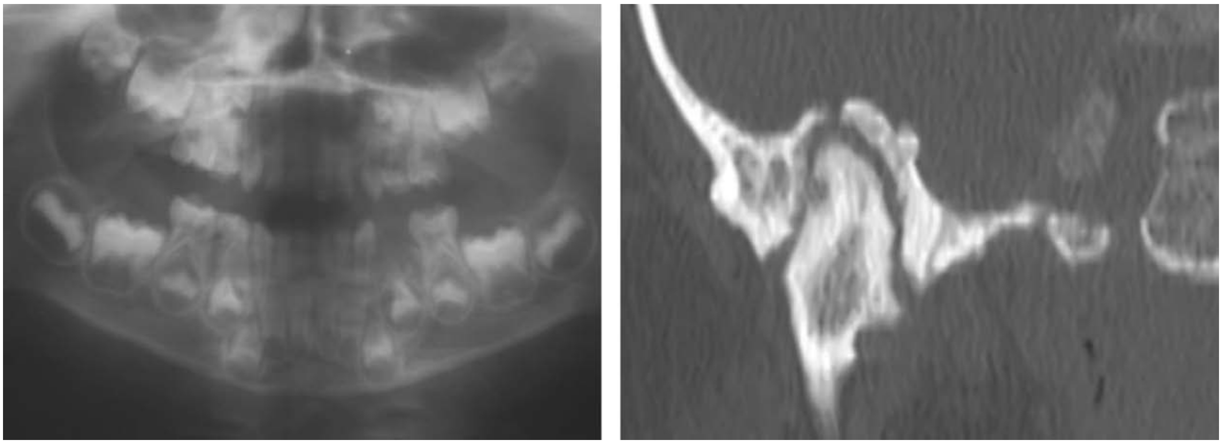


Fig. 3. (*Left*) Developing tooth buds in a child occupy a large proportion of the mandibular body and symphysis. (*Right*) Condylar injury with penetration into the middle cranial fossa.

and how fixation is placed when these fractures need to be stabilized.

When an intraarticular condylar fracture is diagnosed (Fig. 3, *right*), attention must be focused on range of motion. Usually, the occlusion is minimally altered in these situations. Failure to move early predisposes the child to ankylosis as the fibrocartilaginous mass from the injury consolidates. Temporomandibular joint ankylosis is very difficult to treat successfully and, in a child, can result in profound deformities, as the injured side fails to grow appropriately, resulting in progressive deviation of the chin point to the fractured side.[40,45–47] These children should be provided with pain medication and range-of-motion exercises should be encouraged. In condylar neck injuries, there is a greater chance of more significant occlusal problems. This becomes a judgment call. Very young children have remarkable fracture remodeling ability, and the developing dentition can self-correct some degree of malocclusion. A short period of maxillomandibular fixation should be considered for older children or for more significant malocclusions. Standard Erich arch bars can be a challenge in the mixed dentition stage, but can still be used. Some surgeons prefer to use a circummandibular wire joined to a wire passed from above through the piriform aperture.

In fractures of the ramus, body, or parasymphysis, which are all felt to require stabilization, open reduction and internal fixation is probably the best option. Although historically many children were treated with splints, this can require several anesthetics for the dental impressions and the placement and removal of the splint. When using plate fixation, typically, miniplates are sufficient. A preoperative panoramic radiograph is useful in evaluating the position of the developing tooth buds. One must be careful to not damage this during plate placement. As such, plates should generally be placed on the inferior mandibular border.[48,49] Radiographs should also be taken postoperatively to ensure that none of the screws is transfixing a tooth bud. If this is seen, the plate should be removed once the fracture has healed. Routine plate removal is not indicated.

COMPLICATIONS

Mandible fracture complication rates range from 7 to 29 percent and have been correlated to fracture severity.[50–52] In a study in the *Journal of Oral and Maxillofacial Surgery* in 2014, Gutta and colleagues assessed the rate of complications in 363 patients with mandible fractures treated at an academic tertiary care hospital (**Level of Evidence: Therapeutic, IV**).[20] They found that hardware failure was the most common complication (15.4 percent) followed closely by infection (15.1 percent). Higher complication rates were seen among smokers and patients with systemic illnesses. Antibiotic use did not seem to affect the incidence of these complications.

When discussing complications, it is helpful to understand the relationship between hardware failure and infection, as either one can lead to the other. That is, ongoing infection can lead to hardware failure and hardware failure can result in infection. Failure to apply hardware correctly can lead to loose screws or ongoing mobility of the fracture fragments. Frequently, this first manifests as pain and swelling at the operation site. If this occurs early in the postoperative period, most of these patients should undergo exploration. If the hardware has failed, one should consider replacing the hardware, often with a more rigid construct. This notion is true even in the face of gross infection. If the hardware is intact and the fracture is stable, the site should be washed out and the wound closed.

The most significant complication postoperatively is malocclusion, which is essentially always attributable to a technical error in the placement of the fixation. This should never occur if the bite is assessed carefully at the end of the case. One must avoid forcing the patient into occlusion. Rather, with the condyles seated, the mandible should be able to be "tapped" up into occlusion with the maxilla. If it does not, the plate should be removed, recontoured, and reapplied. If noted postoperatively, most patients should be returned to the operating room.

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