Chapter 92 – Fractures of the Mandible

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The mandible is the second most commonly fractured bone in patients sustaining facial trauma.[1] When a mandibular fracture is detected, additional fractures of the mandible or midface should be sought out. Failure to do so will inevitably result in an incomplete or undesirable treatment outcome. The mandible is the thickest bone of the maxillofacial complex. Therefore, with panfacial fractures, adequate mandibular restoration to full continuity often serves as the reference and pillar to re-establishing normal facial contours and projection.

Mandibular fractures are classified by their anatomic location (Fig. 92-1): symphysis/parasymphysis, anterior (between the canine teeth), body (between the canine and second molar), angle (in the third molar region up to the level of the lower occlusal plane), and ramus (at the posterior mandibular vertical component, excluding the condylar process and coronoid). Condyle fractures are further subdivided into subcondylar—below the sigmoid notch (the U-shaped junction of the condyle and the coronoid) and coursing down into the ramal area, the condylar neck (at or above the sigmoid notch), and intracapsular—the condylar head, or articular surface. Dentoalveolar fractures are confined to a tooth or a segment of teeth and their surrounding bone but do not extend down or through the inferior border of the mandible.

These same fractures are also classified as open or closed. By definition, any fracture in a tooth-bearing area is an open fracture. Mandibular fractures will often course along or parallel the tooth roots in the anterior region, thereby resulting in a new gap between the adjacent teeth, a gingival tear, or a heavier radiodense line along the tooth root. With multirooted posterior teeth, the fracture can traverse along a mesial or distal root surface or involve the tooth itself. Generally, fractures of the ramus, condyle, and coronoid are closed unless severe displacement or a penetrating-type injury has occurred. Edentulous mandible fractures, particularly the body, can be open because of an intraoral tear of the thin overlying mucosa.

Fractures of the posterior body, the angle, and the ramus can be classified as favorable or unfavorable based on the direction (the orientation) of the fracture line and the net effect of the masseteric muscle pull under function (Fig. 92-2). Favorable fractures are angled such that with masseteric closing force, the fracture is further reduced or supported. Unfavorable fractures are further distracted by this same force.

General knowledge of the dentition and occlusion is necessary to adequately access and treat mandible fractures. The full adult dentition consists of 32 teeth, including the third molars and wisdom teeth (Fig. 92-3). The teeth are numbered sequentially, starting with the maxillary right third molar (no. 1) and moving forward to the other molars, bicuspids, canines, and incisors and all the way across to the left maxillary third molar (no. 16). The left mandibular third molar is next (no. 17), and numbering continues forward and across the midline to the right mandibular third molar (no. 32). It is prudent practice to routinely "count teeth" and assess for any missing or splayed teeth with concomitant open sockets, gingival tears, or bleeding. These are all telltale signs suggestive of a fracture. The primary dentition also has a nomenclature that uses capital letters (Fig. 92-4).

When discussing a particular surface or a relationship to a tooth, a set of terms is used: mesial refers to the anterior surface (in front of or toward the midline), distal refers to the posterior surface (or away from the midline), lingual identifies the inner surface or tongue side, and buccal/labial/facial all refer to the outer surface or the cheek side.

The most widely used classification system for describing maxillary and mandibular intraoral bite relationships is the Angle system. An Angle class I occlusion is characterized by the maxillary canine being just distal to or behind (half a tooth) the mandibular canine, and the mesial buccal (front) cusp of the maxillary first molar is slotted in the buccal groove of the mandibular first molar (Fig. 92-5).

Although Angle class I is the most common and desirable occlusal relationship, it is not present in all patients before injury. Classification may be different on the right versus the left side. When evaluating a patient with a mandibular fracture, it is important to ask the patient or family whether a preexisting malocclusion was present, specifically, "Were your upper teeth in the front overlapping your lower teeth?" (class I). Additionally, one may ask, "Was your lower jaw recessive/receding or did it jut out?" (class II or class III, respectively). Finally, ask "Did your front teeth not come all the way together or were they gapped vertically?" (indicating an anterior open bite). These queries, along with appropriate radiographs, help avoid surprises and struggles in the operating room when attempting to align the fractures and re-establish the habitual occlusion. Wear facets on the teeth and interdigitation of the bite are useful aids in determining more precise fracture alignment.

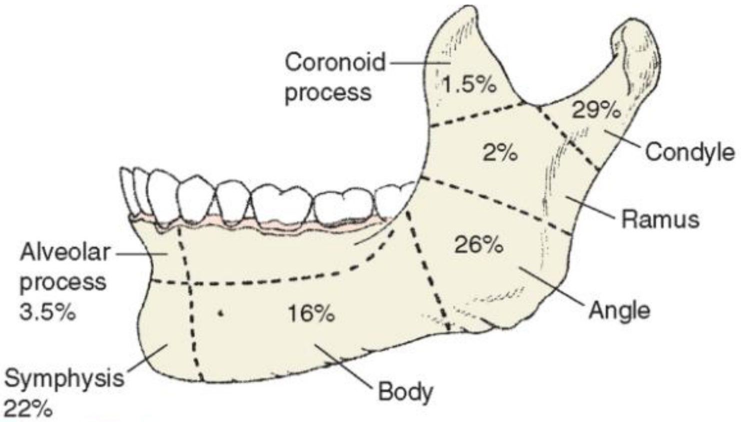

Figure 92-1. Anatomic classification and percent distribution of mandibular fractures in dentate adult patients.

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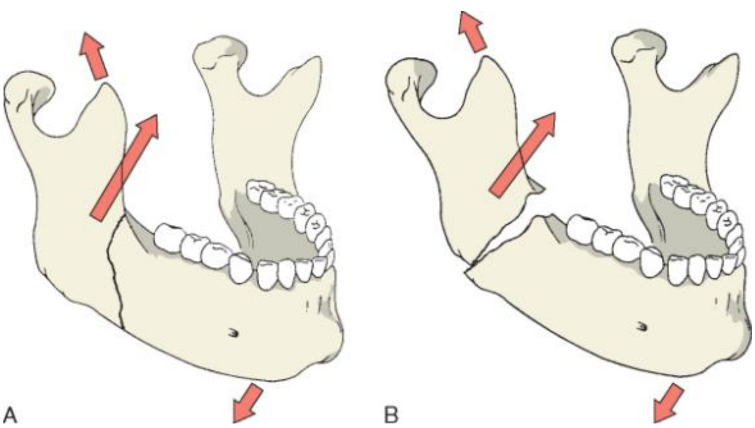

Figure 92-2 **A,** Favorable mandibular angle fracture. With the muscular pull of the temporalis and masseter and the minor influence of the digastrics and suprahyoid musculature, there is a tendency toward further fracture reduction or stabilization. **B,** Unfavorable mandibular angle fracture. With these same muscular forces there is a tendency toward gapping at the superior border and rotation of the proximal or angle segment upward. This bony step can also be palpated intraorally.

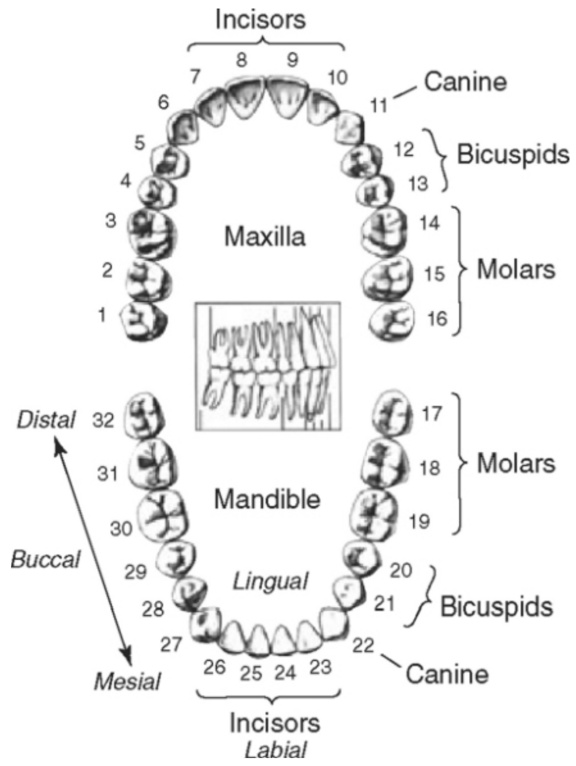

Figure 92-3 Adult/permanent dentition with numbering system and descriptors that help accurately describe the relationship of an injury or abnormality relative to the dentition.

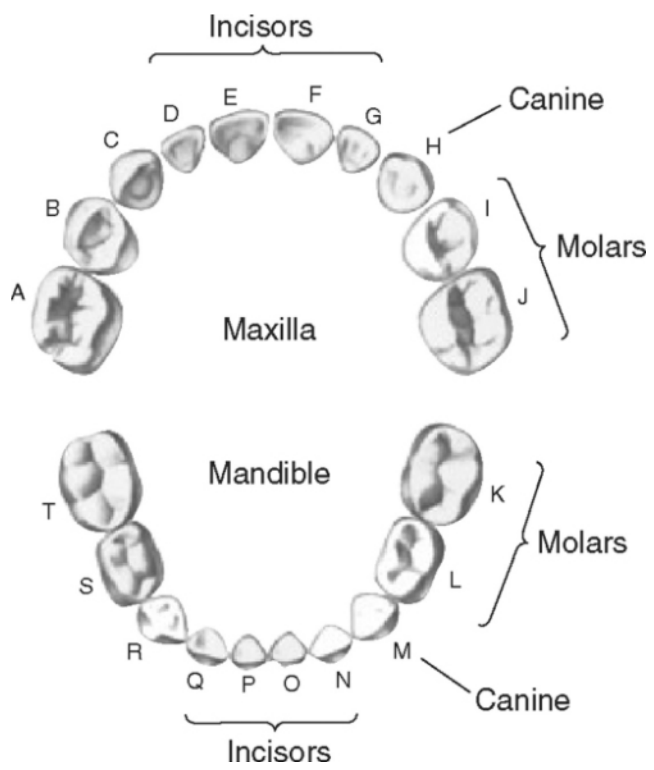

Figure 92-4 The pediatric/primary dentition with alphabetic designations.

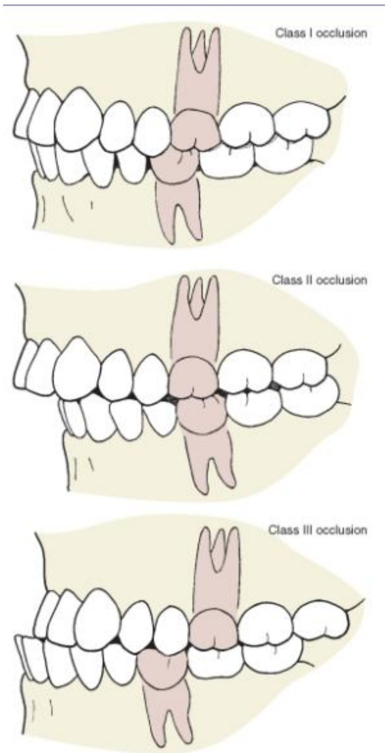

Figure 92-5 Angle's classification of occlusion. In class I occlusion, the mesial buccal cusp of the maxillary first molar fits into the buccal groove of the mandibular first molar. In class II occlusion, the mandibular first molar is distal relative to the maxillary first molar, a consequence of mandibular retrusion. If the mandible is prognathic (class III occlusion), the mandibular first molar is completely in front of the maxillary first molar.

PATIENT SELECTION

Patients with mandibular fractures may have the classic signs and symptoms: pain, trismus (difficulty opening), swelling, malocclusion, gingival tear, ecchymosis of the floor of the mouth, bony crepitus on functioning, and paresthesia or anesthesia of the lower lip and chin (cranial nerve V_3 distribution).[2] The most common initial complaints are pain and malocclusion. The paresthesia or anesthesia is generally due to swelling or a direct injury to the inferior alveolar nerve cable somewhere along its course through the mandibular canal from the lingula/medial midramus to the mental foramen (exiting below and between the apices of the mandibular bicuspid teeth). This would be indicative of fracture of the body, angle, or ramus. Focal preauricular pain during active jaw motion or palpation is suggestive of a condylar or subcondylar fracture. Floor of the mouth ecchymosis is typically seen with symphyseal fractures, especially in edentulous elderly patients.

Unless there is gross fracture displacement in a thin individual, it is difficult and painful to palpate a bony step. A more productive maneuver is to gently flex the mandible across the suspected fracture site to detect mobility, gapping of teeth, or widening of a gingival/mucosal tear.

PREOPERATIVE EVALUATION AND PLANNING

Once a clinical diagnosis of a mandibular fracture is established, it is important to query the patient about any preexisting malocclusion; any previous fractures, injuries, or surgery involving the jaws or the temporomandibular joints; and any previous orthodontic treatment (generally indicates a class I or more favorable occlusion, but not always). After the initial clinical examination and history, selective radiographs can be obtained to determine the specific location, extent, and characteristics of the fracture. The radiographic studies must fully evaluate the entire mandible because multiple fractures are fairly common. A parasymphyseal or body fracture will often have an associated contralateral subcondylar fracture. The two best initial radiographic studies are a panoramic tomogram (Panorex) and an open-mouth reverse Towne view to further assess condylar fractures.[3] If the findings are equivocal or the study is not diagnostic, it can be repeated or additional mandibular views can be taken, such as posteroanterior (best for the symphyseal area), lateral (images the body and angle well), or oblique (visualizes the body, angle, and ramus well and the condylar neck less reliably). The quality and diagnostic accuracy of the mandible series can be diminished if a portable study is performed or the patient is in a cervical collar, which hampers positioning and leads to structural overlap. In any event, if more definitive imaging is required, a computed tomography (CT) scan with axial cuts ranging from 5 to 1.5 mm is indicated. Intravenous contrast enhancement is not indicated and provides no additional information in the acute trauma setting. Direct coronal views can be helpful in ascertaining the exact pattern and alignment of condyle fractures, particularly intracapsular ones. Three-dimensional reformatting is generally unnecessary and adds further expense. If there is any suspicion of maxillary, midfacial, or skull fractures, the axial CT scan should be continued through these regions as well.

Once all the radiographic studies have been reviewed, it is often helpful to re-examine the patient so that issues such as suitability and number of teeth for arch bars, soft tissue swelling, and associated lacerations can be incorporated into the surgical treatment plan and the approaches to be used.

The timing of treatment of mandibular fractures depends on many factors, but in general it is better to treat a fracture as soon as possible. Evidence shows that the longer an open or a compound fracture is left untreated, the greater the incidence of infection.[4] Antibiotics have been shown to decrease the risk of wound infection in patients with mandible fractures.[5] Antibiotics with appropriate activity against oral bacteria can be initiated upon diagnosis and administered for several doses after surgery. Grossly contaminated wounds or open defects may warrant longer therapy. In addition, delay of several days or weeks makes ideal anatomic reduction of a given fracture difficult, if not impossible, particularly for condylar and subcondylar fractures. Furthermore, progressive edema 2 or 3 days after surgery frequently makes surgical access and soft tissue dissection more difficult.

However, treatment of facial fractures is frequently delayed for several reasons. In many cases, other more serious or life-threatening injuries are present, and the patient is not neurologically or hemodynamically stable enough to undergo general anesthesia and a surgical procedure. Moreover, it is highly desirable to have the cervical spine cleared of any injury and to have the cervical collar removed before surgery, especially with any extraoral approaches and open treatment of condyle fractures. Infrequently, excessive soft tissue edema or anticoagulation requires a 3- to 4-day delay in surgical treatment.

The primary goals of treatment of mandibular fractures are to restore continuity of the mandible and return to the patient's habitual functioning occlusion. In addition, consideration should be given to maintaining acceptable facial and dental aesthetics and minimizing neurosensory or facial nerve impairment. During the treatment and healing phases it is also important to maintain adequate nutritional status and minimize patient discomfort and inconvenience. Therefore, patients with neurologic injuries, preexisting mental disabilities, or seizure disorders may not be suitable candidates for closed treatment and the use of postoperative maxillomandibular fixation (MMF). Finally, preoperative assessment of the patient's nasopharyngeal airway should be undertaken because nasoendotracheal intubation and intraoperative interdental fixation are almost always necessary for treatment of a dentate mandibular fracture. Septal deviation, turbinate hypertrophy, bleeding, and coagulopathies are several factors to be considered.

SURGICAL APPROACHES

Fractures of the mandible can be treated in either closed or open fashion. The surgeon needs to consider the adequacy of the teeth with regard to number, the amount of decay or periodontal disease present, extensive crown and bridge work, and opposing dentition to maintain the bite relationship. Generally, a patient must have the majority of teeth in all four quadrants of the mouth for closed treatment and 6 weeks of MMF to be effective. Circumdental wiring and arch bars may only add further stress to an already compromised dentition.

The decision whether to treat a mandibular fracture by either open or closed means may be heavily influenced by concomitant injuries and fractures at other mandibular sites or associated facial bones.[6,7] More extensive concomitant facial injuries may prompt opening and rigid plating of all mandible fractures to restore facial proportions and projection or to assist in closed reduction or a period of postoperative MMF for less stable midfacial fractures.

Most mandible fractures can be opened and plated from an intraoral or extraoral approach. In general, it is easiest to approach and plate parasymphyseal fractures transorally. Condyle fractures, when opened, are best approached extraorally via a modified submandibular or retromandibular dissection and, very infrequently, via a preauricular dissection. The decision to open a mandibular body, angle, or ramus fracture, either intraorally or extraorally, should be based on a specific fracture pattern, soft tissue swelling, ease of access, and the surgeon's preference. Surgical planning should take into account these factors and the possibility of combined approaches such as an intraoral vestibular incision and percutaneous drilling and screwing through a cannula.

Arch Bar Application

Proper treatment of mandibular fractures in dentate patients usually begins with the application of prefabricated arch bars. The teeth are gently brushed with a preparative solution and rinsed to clear any clots or debris. A moist throat pack is then inserted to prevent loss of any wire trimmings into the hypopharynx. It is helpful to infiltrate a local anesthetic with 1:100,000 epinephrine throughout the maxillary and mandibular vestibule because annoying oozing can occur in patients with preexisting gingival inflammation. The segment of arch bars is cut to appropriate length for at least first molar–to–first molar engagement (preferable to include the second molars) around the arch. The arch bar is gently bent into a curve and preadapted to the dental arch at the level of the necks of the teeth and the free gingival margin (Fig. 92-6). Usually, posterior teeth (bicuspids and molars) are ligated to the arch bar with 24-gauge stainless steel wire, and anterior teeth are secured circumdentally with 26-gauge wire. It is easiest to start with the first bicuspids because they have a bulbous shape that is favorable for seating of the wires below the height of contour. As the wires are tightened, the arch bars should be held in proper anteroposterior alignment and snug against the cervical margins of the anterior teeth. One limb of the wire is passed under the bar and one over the bar on return from the lingual pass and twisted in a clockwise direction while fully seating the wire around the neck of the tooth with a forked wire director (see Fig. 92-6B). This is most important for canine and anterior teeth, which are slender and have minimal undercuts to resist dislodgement when the MMF wire loops are tightened to bring the patient into full occlusion.

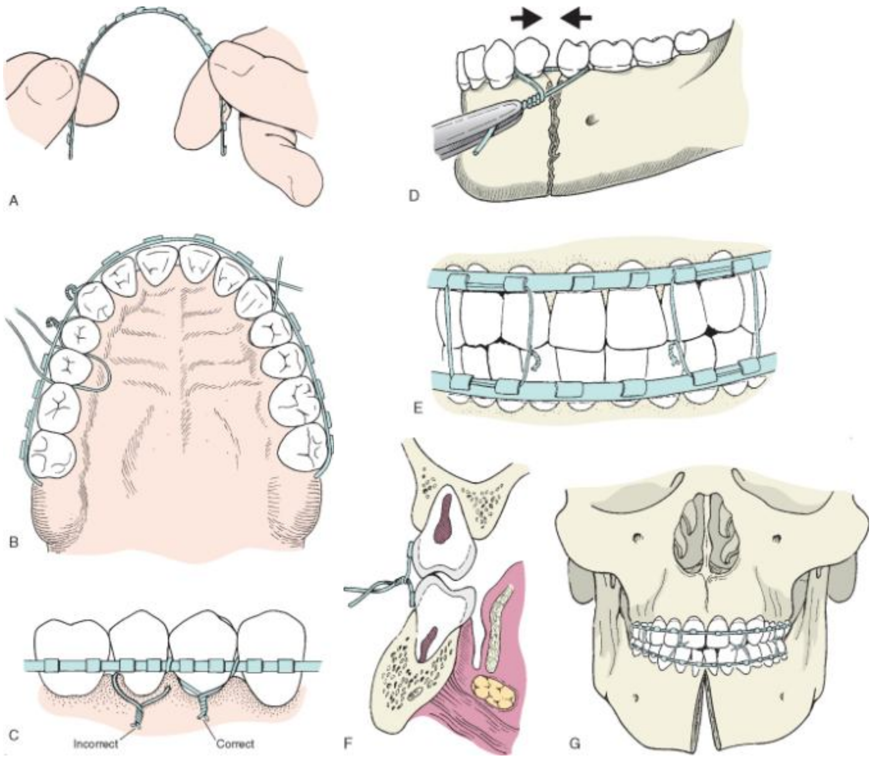

Figure 92-6 Technique of placement of arch bars and maxillomandibular fixation (MMF). **A,** The arch bar is cut and bent to the appropriate length and shape of the dentition, including all stable teeth, for fixation. **B,** The arch bar is fixed to the posterior teeth with 24-gauge circumdental wire and to the anterior teeth with 26-gauge circumdental wire. It is often helpful to start in the bicuspid regions because these teeth have undercuts that engage the circumdental wires well and seat the arch bar at the cervical margin of the teeth. The wires pass above the bar on one side of the tooth and below the bar on the other side and are then twisted in a clockwise direction. **C,** The wires should pass between the tooth and the interdental papilla to avoid strangulation of these structures. **D,** A bridal wire is passed around the first and second bicuspids with a left mandibular body fracture to aid in reduction and stabilization. This is done before fixation of the arch bar and allows the arch bar to be secured to the mandible in an already reduced position. **E,** MMF, or wire loops, are placed between the upper and lower arch bars to maintain dental occlusion during fixation of the fracture. **F** and **G,** Overtightening the MMF wires in the presence of a symphyseal or parasymphyseal fracture will cause the inferior border of the fracture to splay apart with accompanying lingual version of the occlusal surface. If this is not detected, adequate reduction of the fracture is not possible.

The wires should lie on the surface of the teeth and not pass through or around the interdental papillae (see Fig. 92-6C). When fractures of the mandibular body or parasymphyseal region are present, a wire may be looped around the teeth adjacent to the fracture site and gently tightened until proper fracture alignment has been achieved (see Fig. 92-6D). Placement of the arch bar can then continue distally to the site of the fracture; the fracture must be properly reduced at the superior mandibular surface. If the arch bar interferes with reducing a fracture, it can be sectioned at the fracture site to allow proper alignment. After the arch bars have been placed in stable fashion on both the maxillary and mandibular dentition, MMF is performed (see Fig. 92-6E). It is important to not overtighten the MMF wires, especially with fractures of the parasymphyseal region, because the inferior fracture gap will widen (see Fig. 92-6F and G) and result in “lingual version” of the mandibular dentition.

When the dentition is inadequate to completely stabilize an arch bar, the arch bar may be further secured with circum-mandibular wiring for the mandibular arch bar and wiring of the piriform aperture or circumzygomatic wires for the maxillary arch bar (Fig. 92-7). The skeletal fixation wires provide added stability.

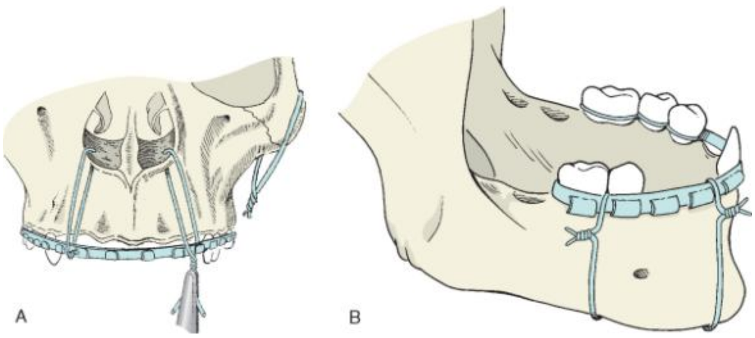

Figure 92-7 **A,** When the maxillary dentition is inadequate for fixation, suspension wires can be passed through the piriform aperture and tied directly to the arch bar, or circumzygomatic wires can be passed and an intermediate loop of wire can engage the lower arch bar or be secured to a circum-mandibular wire (**B**), which can also help retain a lower arch bar with inadequate dentition. Generally, 24-gauge wire is used for skeletal fixation wires, and lighter wire (26-gauge) is used for any intermediate loops that lock the skeletal fixation wires to each other.

Several important considerations must be kept in mind for proper placement of arch bars. A circumdental wire should not pass through the interdental papilla of the gingiva because necrosis of this important structure can occur. The wires should be carefully positioned directly adjacent to the tooth and slid beneath the gingiva to avoid gingival necrosis. Before tightening the wires around the bars, the two ends of the circumdental loop should be adjusted so that they are of equal length and form an isosceles triangle. If the ends of the wire are of equal length, they will firmly anchor the arch bar to the teeth as the wires are carefully twisted under tension. Wire twisting is always performed in a clockwise direction so that other surgeons will know which direction to twist for tightening or removal postoperatively.

Dental and Dentoalveolar Fractures

Teeth can be individually fractured through the crowns at various levels. Management of fractures of the teeth is individualized according to the severity of the injury.[8] Even if the pulp is exposed and the tooth is fractured off at the base of the crown, these teeth should be maintained and can be restored with endodontic treatment (root canal) and crowns. Teeth that have been subluxated or dislodged should be manually repositioned within the socket and dental arch. It is usually best to secure the injured tooth or segment of teeth to the adjacent dentition with a braided wire and bonding agents (such as cured resins, which are used by orthodontists to apply brackets to the teeth). If a dental specialist is not available for assistance, temporary stabilization with less tightly applied arch bars can suffice until more definitive treatment is rendered. Overtightening the circumdental wires merely serves to extrude and extract the injured or subluxated teeth. Large dentoalveolar fracture segments (four or more teeth) are more amenable to arch bar stabilization or miniplating (or both). Totally avulsed teeth need to be reimplanted within 1 hour for a reasonable prognosis. The tooth should be bonded to the adjacent teeth. Teeth that have sustained root fractures are not usually salvageable and should be removed.

Symphyseal and Parasymphyseal Fractures

Either an intraoral or an extraoral approach can be used for symphyseal and parasymphyseal fractures. The intraoral approach requires less tissue stripping and is quicker. Once the arch bars are in place, fairly snug but not overtightened MMF should be instituted to avoid splaying of the inferior border. The MMF is secured before soft tissue dissection and the mandible supported, which offers resistance when undermining the periosteum and mentalis muscle. Dissection should be carried out to the inferior border. A toe-up Obwegeser or symphyseal retractor aids in stabilization and retraction. With the lip retracted and stretched slightly, the vestibular mucosal incision should be 1 cm away from the mucogingival junction. This will allow stronger multilayered closure of both muscle and the mucosa and will also help avoid postoperative oral dehiscence with plate exposure. In addition, the incision heals more comfortably within the depth of the vestibule. Once adequate exposure is gained for plating (usually a 3- to 4-cm incision), the fracture can be gently splayed by inserting a Freer or periosteal elevator and twisting lightly. The fracture margins should be irrigated and gentle curettage performed to remove all debris, trapped muscle, small bone fragments, clot, or fibrin. This is especially important for fractures that are being treated more than 48 hours after injury. The MMF is then snugged and tightened while placing gentle inward extraoral pressure on the bilateral angle or body regions. Inward bilateral angle pressure helps prevent inferior and labial bone gapping. Generally, a superior four- to six-hole tension band plate (2.0-mm system) is adapted and secured with monocortical screws (4 to 5 mm in length) (Fig. 92-8). Before fixating the plate, the occlusion and fracture alignment should be checked. A previously placed bridal wire (see Fig. 92-6D) can assist in gaining firm interdental contact. The superior monocortical plate should be placed below the roots of the incisor and canine teeth. The outline of the roots may be visible, or placement of the plate 22 to 24 mm (incisors) or 26 mm (canine) below the incisal edges provides safe clearance. Generally, an ideal and safe place for plating is at the level of the greatest concavity of the mandible, where the alveolar process meets the chin. The screw holes should be carefully centered and a drill guide used. The circumdental and MMF wires will not resist displacement caused by improper eccentric drilling.

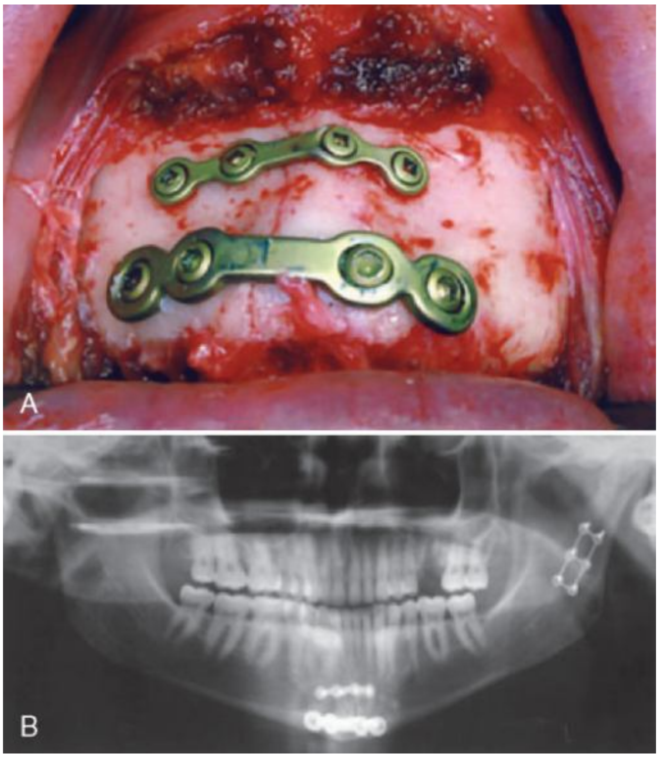

Figure 92-8 **A,** Transoral approach and plating of a symphyseal fracture. A superior monocortical tension band plate (2.0-mm system) and a heavier inferior border fracture plate (2.7-mm system, bicortical screws) can be used. **B,** The patient was treated with arch bars, was maintained in maxillomandibular fixation (MMF) during fracture reduction plating, and underwent an extraoral approach for the treatment of a left subcondylar fracture. On the release of the MMF wires, the occlusion was checked and found to be stable and reproducible. The arch bars were then removed and soft tissue closure performed.

When an inferior border plate is adapted, I generally use a slightly heavier fracture plate (or compression plate) for this purpose—one that cannot be bent with finger pressure alone. Slight judicious contouring of any gross bony irregularities (preexisting irregularities, not improperly reduced fracture margins) facilitates plate adaptation and optimal contact with the facial cortical bone. A four- or six-hole plate with a small center span is ideal because most fractures have some degree of obliquity. It is best to avoid traversing the fracture line with the bicortical screws. With the MMF secure and the superior tension band plate in place, the fracture is stationary and maintains its position while adapting and securing the heavier inferior border plate, which will more readily resist movement and masticatory and functional force during healing. Once adapted and flush to the bone, it is helpful to overbend the heavier fracture plate slightly in the central portion so that it is raised 0.5 mm off the bone surface.[9] During screw tightening, this will help minimize unfavorable lingual gapping and posterior flaring or widening of the mandible (see Fig. 92-6). These heavier plates are generally secured with 2.3- to 2.7-mm-diameter screws systems. It is important to use drill guides because eccentric hole placement will cause a shift in the bone fragments and malocclusion. It is sound surgical practice to place at least two screws on each side of the fracture line within each plate (i.e., a minimum of four screws per plate). This prevents pivoting and rotational movement. A single, nonrigid 2.0-mm plate can be used for fracture stabilization if the patient is being maintained in MMF for 6 weeks because of other facial fractures. In addition, some surgeons prefer to use 2.0-mm plates for both the superior tension band and the inferior bicortical plate. It is possible to use a lag screw technique without a plate for oblique fractures of the symphysis, but this method is rather technique sensitive, and any minor drilling malalignment will result in a noticeable and unforgiving malocclusion, usually with a step in the dental arch.

After rigidly fixating the fracture, if there are no other mandibular fractures to treat, the MMF wires (not the circumdental wires) can be cut and removed and the occlusion checked. It is best to push upward on the bilateral angles externally to gently seat the condyles during closure. If the result is satisfactory and stable, muscular closure is performed with several 4-0 Vicryl (braided polyglactin) sutures, and the mucosa is closed with 3-0 or 4-0 chromic suture in a running horizontal mattress stitch. If the arch bars are not to be maintained, they should be removed before soft tissue closure. In general, I do not leave arch bars on postoperatively unless the patient is to be maintained in MMF or if there is some need for elastic guidance. Arch bars without MMF are inadequate to provide stability at the alveolar level and should not be relied on to serve as a superior tension band or to provide “fixation.”

If an extraoral approach is to be used, the 4- to 5-cm curvilinear incision line should be placed in the submental region so that it is not visible from the frontal view. The incision should be centered around the point at which the fracture crosses the inferior border of the mandible.

Body Fractures

Fractures of the mandibular body are readily exposed via an intraoral mucosal approach. There are scant muscle attachments and little tissue thickness to traverse during dissection. The mucosa and deeper tissues are infiltrated with local anesthetic and a vasoconstrictor to minimize bleeding and optimize visualization. Reinjection during surgery is more advisable than cautery, especially in proximity to the mental nerve. As previously described, the 5- to 6-cm mucosal incision is made 1 cm lateral or inferior to the mucogingival junction. Along the anterior extent a mucosal-only incision is made, and blunt dissection with small curved hemostats helps identify and free the mental nerve from the anterior or labial flap of soft tissue. The mental nerve exits the mandible between the root tips of the bicuspid teeth. This nerve should be preserved and protected throughout the procedure. It is best to perform dissection with the teeth in MMF because MMF allows more lateral and inferior posterior retraction of the lip, cheek, and commissure of the mouth. A toe-up Obwegeser retractor beneath the inferior border of the mandible helps provide excellent retraction and visualization. Excessive torquing on the obwegeser retractor or body retractor can cause the fracture segments to splay laterally. A single heavier fracture plate can be readily adapted along the typically flat, broad surface of the body's inferior border. The lower edge of the plate should be even with the lowest edge of the mandibular inferior border (Fig. 92-9) to allow proper drilling and bicortical screw placement and avoid injury to the inferior alveolar nerve. Generally, the anterior screws are easily placed transorally, and because of the limits of cheek and lip retraction, added safety is provided by angling slightly inferiorly as one proceeds medially. If necessary, a trocar, cannula, and guard can be used to percutaneously drill and place screws in the posterior plate holes. These are done last because the plate is already stabilized and held in place with the anterior screws. Therefore, the surgeon can concentrate on centering the hole with the aid of a drill guide within the cannula and create a perpendicular path for screw insertion. In most instances there is adequate room above the inferior alveolar canal and below the tooth root apices for a monocortically fixated tension band plate (Fig. 92-9B). If the fracture is located more toward the anterior body region, the monocortical superior plate must “straddle” it above the mental foramen. Remember that the mental nerve has a genu as it exits the mandible. The nerve courses upward and posteriorly several millimeters as one proceeds anteriorly. Therefore, the inferior alveolar canal and nerve are slightly below the level of the mental foramen. A panoramic radiograph is invaluable in assessing this relationship and clearance relative to the nerve canal and root apices. The occlusion should be checked frequently during fracture reduction and fixation to help ensure restoration of preinjury alignment.

Figure 92-9 Right body and left subcondylar fracture of the mandible. **A,** Panoramic radiograph demonstrating a slightly oblique fracture of the right mandibular body with mild displacement and vertical overlap of the left subcondylar segmer inadequate dentition, particularly in the left posterior maxilla, to re-establish a proper vertical dimension through maxillomandibular fixation (MMF) alone. **B,** A transoral approach to the right body fracture was made after placing the patient in M monocortical tension band, four-hole miniplate was applied above the mental nerve, and a four-hole heavier fracture plate was applied at the inferior border, with the distal screws angled inferiorly to avoid the inferior alveolar nerve canal. **C,** Le submandibular/retromandibular approach to the displaced subcondylar fracture. Note that the inferior edge of the proximal segment is laterally displaced. This is quite classic because the pull of the lateral pterygoid on the condylar head displa medially. When dissecting subperiosteally, this segment often falls underneath the dissection and must be palpated and retrieved from the superior flap. **D,** The reduced left subcondylar fracture, which was fixated with a ladder plate and a locki Intraoperatively, the MMF and arch bars were removed, and the patient was allowed to ingest a soft diet. **E,** A lateral cephalogram taken the first postoperative day shows good preservation of the posterior vertical dimension and projection of Panoramic radiograph demonstrating postoperative reduction and fixation of the right body and left subcondylar fractures.

If the extraoral approach is chosen, a transverse incision is made at least two finger breadths below the inferior border of the mandible and carried down through the platysma and then the fascia overlying the submandibular gland to protect the marginal mandibular branch of the facial nerve. It is usually helpful to have a nonparalyzed patient and a nerve stimulator to test any questionable branches or nerve-like structures. The mandible is then exposed by excising the periosteum on its inferior border. Elevation of the periosteum allows wide exposure of the mandible and placement of mandibular reduction clamps when necessary. The extraoral approach may provide better exposure if the mandibular body is comminuted. After the mandible is plated, the MMF is again released, the occlusion is checked, and the arch bars are removed before tissue closure.

Angle Fractures

Mandibular angle fractures are often associated with an impacted or partially erupted third molar (wisdom tooth). Nondisplaced fractures can be treated in closed fashion with 6 weeks of MMF. No MMF plus a soft diet as the sole treatment is not recommended because malunion or unfavorable occlusal changes will develop in a significant proportion of patients. Completely impacted third molars that do not interfere with fracture reduction may be left in place. In fact, removal may cause excessive distraction of the segments and a significant bony void. If a tooth is partially erupted or fractured or interferes with reduction, it should be removed completely. Removal may include vertical sectioning of the tooth with a fine (1.5 mm) fissure burr and high-speed (100,000 rpm) drill with copious irrigation. The tooth fragments can then be split and elevated out independently. Either intraoral or extraoral exposure can be used. Arch bars are placed before soft tissue surgery. The intraoral approach is similar to that described for a body fracture, except that it is located somewhat more superior along its posterior extent and overlies the external oblique ridge (Fig. 92-10). If a partially erupted third molar is being removed, the incision should course along the lateral exposed crown (the sulcus) and fade back out to the lateral oblique ridge posteriorly to allow primary closure of the tooth socket. Wider tissue dissection with subperiosteal stripping is needed to facilitate lateral retraction and visualization. It is sometimes easier to perform the soft tissue dissection and fracture reduction before placing the patient in MMF. A straight or gently curved monocortical miniplate is usually placed along the lateral aspect just beneath the external oblique ridge (see Fig. 92-10B). Screws can be inserted either transorally or percutaneously, depending on soft tissue stretch and access. Another miniplate or heavier fracture plate is typically applied along the inferior border, often angling upward at the posterior extent but still below the inferior alveolar nerve canal. When placing the cannula and trocar percutaneously, it is best to first sound the proposed skin puncture site with a long anesthetic needle and see whether it corresponds to the fracture line or the center of the planned percutaneous screw placement (Fig. 92-11). Sounding helps avoid the necessity of making additional stab incisions and replacing the cannula at a different site. I do not prefer to use preformed mandibular angled fracture plates transorally. They are difficult to adapt, and any eccentric drilling of the screw holes within the plate tends to create exaggerated unfavorable vectors and displacement of the bony segments.

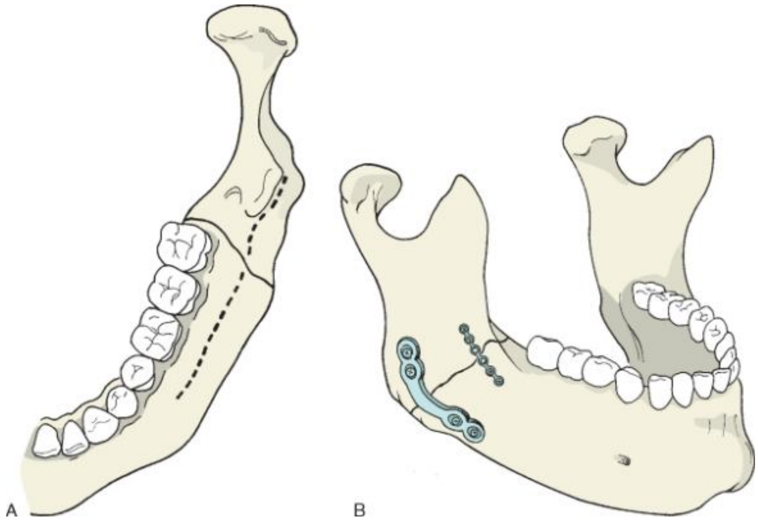

Figure 92-10 Left angle fracture of the mandible. **A,** Incision line for a transoral approach to the fracture. **B,** A six-hole tension band plate is adapted along the external oblique line. There is no center span in this plate and the central plate holes were too close to the fracture line, so no screws were placed in them. Doing so may have caused crazed lines or the screws may have traversed into the fracture line itself. The inferior border angle plate is usually applied via a percutaneous approach with cannula and a drill guide.

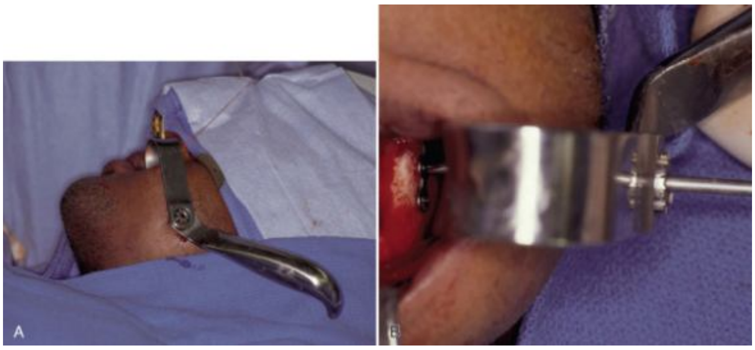

Figure 92-11 Left mandibular angle fracture. **A,** After intraoral dissection and placing the patient in maxillomandibular fixation, a 25-gauge anesthetic needle was used to sound the proposed percutaneous stab incision site, which was then stretched slightly with a small hemostat and a cannula with a trocar was inserted and a cheek guard placed. **B,** The operator is then able to view the fracture and plate transorally while using the percutaneous access to drill and, as seen here, to place screws along the lateral cortex of the mandible.

If the angle fracture is approached extraorally, a skin incision is made approximately 2 to 2.5 cm below the inferior border of the angle and carried slightly upward toward the earlobe at the posterior extent (Fig. 92-12). The incision should be of adequate length (5 cm) to allow retraction and exposure while plating. Blunt dissection with slight undermining of the deep subcutaneous layers is performed. The platysma is divided at the lower extent of the dissection, as is the superficial layer of the deep cervical fascia, while testing for the marginal mandibular branch of the facial nerve (Fig. 92-12B). This branch is just inferior to the tail of the parotid gland. The incised layers and skin flaps are retracted superiorly to expose the pterygomasseteric muscle sling and the periosteum of the mandible. This is incised and widely dissected subperiosteally. The fracture is then gently débrided, irrigated, and reduced while placing the patient in MMF. A four- or six-hole straight or gently curved monocortical (2.0 mm) plate is applied superiorly just below and along the external oblique lines. A four- or six-hole heavier mandibular plate is then applied bicortically along the inferior border and below the inferior alveolar canal (see Fig. 92-10B). After all fractures are plated, the MMF should be released and the occlusion checked. The wound is then irrigated and closure performed with continuous locking 4-0 Vicryl in the platysma and interrupted buried sutures subcutaneously. The cuticular layer is closed with interrupted or continuous 5-0 or 6-0 nylon. Suction drains are rarely indicated, and a gentle pressure dressing or facial support helps prevent postoperative hematoma formation.

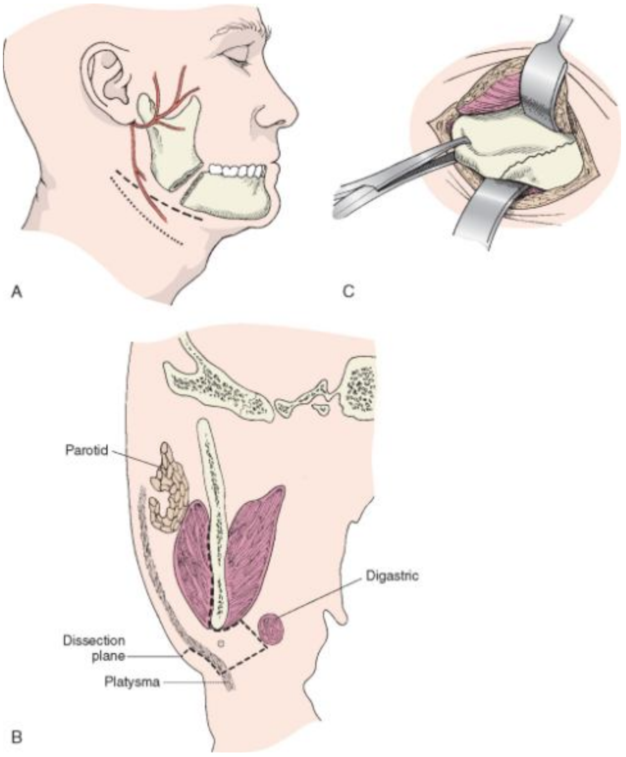

Figure 92-12 External approach to a mandibular angle fracture. **A,** The skin incision is centered around the fracture and designed so that it is just inferior to the angle of the mandible, parallel or within cervical skin creases *(dashed line)*. By making the skin incision high in the neck, the length of the incision can be minimized (approximately 4 to 5 cm). The platysma muscle will be cut more inferiorly in the neck at the traditional level *(dotted line)* to preserve the marginal mandibular branch of the facial nerve. **B,** Cross section through the region of the mandibular angle showing the avascular plane of dissection that allows easy access to the mandibular angle. The facial nerve branches are protected by initially dissecting inferiorly into the neck. The dissection then proceeds to the digastric muscles, where the point of dissection is deep to the facial nerve. The mandibular periosteum is incised on the inferior border of the mandible. **C,** Exposure of a reduced fracture through an extraoral approach.

Ramus, Condyle, and Coronoid Fractures

Coronoid fractures are uncommon and usually associated with a zygomatic complex fracture that has been driven inward. Coronoid fractures do not require closed or open treatment. They heal uneventfully on their own, except if an overlying zygomatic complex is not properly reduced and is in close proximity, thereby risking fibro-osseous union of the entire coronoid and zygomatic complex fracture.

Ramus fractures can be treated satisfactorily by closed reduction and 6 weeks of MMF. Transoral approaches for plating are difficult. The external skin incision plus approach for ramus fractures is similar to that for angle fractures but with more extension superiorly and with subperiosteal dissection and retraction. Y plates, L plates, and "box" or "ladder" plates allow several screws to be placed in the proximal superior segment closer to the fracture line and decrease the need for further superior dissection and retraction (see Fig. 92-9E and F).

Condylar and subcondylar fractures can be treated with 2 to 4 weeks of MMF. If the fracture is intracapsular (head of the condyle), 2 weeks is appropriate to limit the risk for ankylosis.[10] When a unilateral subcondylar fracture is associated with other mandibular fractures, open reduction with rigid fixation of the coexisting mandibular fractures is indicated so that the subcondylar fracture can be mobilized and returned to function at 2 to 4 weeks (Fig. 92-13).

Figure 92-13 **A,** A young man was evaluated for pain and malocclusion with shift of the lower jaw to the left and premature occlusal contact on the right posterior teeth. An open-mouth reverse Towne view (**B**) and a Panorex view (**C**) demonstrate the left condyle fracture with overlap and a right body fracture gapping between the second bicuspid and first molar. **D,** The patient underwent placement of arch bars, maxillomandibular fixation (MMF), and a transoral approach to the right body fracture with placement of a heavy fracture plate along the inferior border. Adequate reduction and posterior vertical dimension were re-established by keeping the patient in 2 weeks of MMF. **E,** Postoperative occlusion at 6 weeks. The bars were removed at week 4. Between weeks 2 and 4, some light box elastics were placed on the right side and anterior arch bar regions to help guide the occlusion.

Open reduction and plating of condyle fractures may be indicated[11] and is necessary in the following situations:

1. Displacement of the condylar head into the middle cranial fossa
2. When condylar displacement prevents re-establishment of proper occlusion
3. With lateral or severe displacement of the condylar head out of the fossa
4. When a foreign body, such as a bullet or bone fragment, is lodged within the temporomandibular joint capsule

5. Open fractures with extensive soft tissue injuries (gunshot wounds) in which early function can help minimize fibrosis

Other relative indications include bilateral condyle fractures associated with midfacial fractures or bilateral condyle fractures in an edentulous patient. In these situations, open reduction of one or both condylar fractures greatly aids re-establishment of proper facial dimensions. When significant displacement has resulted in the loss of posterior vertical height, open reduction with rigid fixation is usually recommended (see Fig. 92-9). Severely comminuted intracapsular condyle fractures are not amenable to plate-and-screw fixation and result in only more soft tissue trauma. These patients should be treated with 2 weeks of MMF and then guided (elastic) function as necessary for several more weeks.

When open reduction of a condyle fracture is performed, it is generally through a skin incision similar to that for angle fractures, with a posterior tail that is within 2 cm of the ear lobe. Infrequently, condyle fractures are exposed through a preauricular incision to allow retrieval of a medially displaced condylar head. The preauricular incision is usually performed in conjunction with the submandibular/retromandibular angle approach so that reduction and plating of the fracture are possible without excessive inferior retraction and stretch from above, which might place the facial nerve and superior branches at risk. Condyle fractures (adult or pediatric) should not be approached intraorally. Careful planning and multiple techniques are often needed, even with extraoral approaches. Treatment of mandible fractures should be undertaken by surgeons familiar with the surgical approaches, and it is beneficial to have another surgeon assisting. Judicious stripping and muscular reflection for 1 to 1.5 cm on the medial surface of the inferior angle will greatly improve the ability to retract superiorly. In addition, a channel or toe-up Obwegeser retractor placed in the sigmoid notch will enhance visualization and access to the condyle fracture. Plate configurations that allow several screws to be inserted within the condylar segments close to the fracture line will facilitate plating (see Fig. 92-9D).

Endoscopically assisted reduction plus plating of condyle fractures has been advocated by several authors, but it has limitations and has not been shown to be more efficacious or to have less risk than traditional approaches.

Pediatric mandible fractures (≤6 years of age) are usually best treated with closed techniques involving the use of skeletal fixation wires and sometimes acrylic interocclusal splints (Fig. 92-14). Because of immature bone, limited bone stock, and developing permanent tooth buds, children's mandibles are difficult to plate effectively,[12] especially condyle fractures.

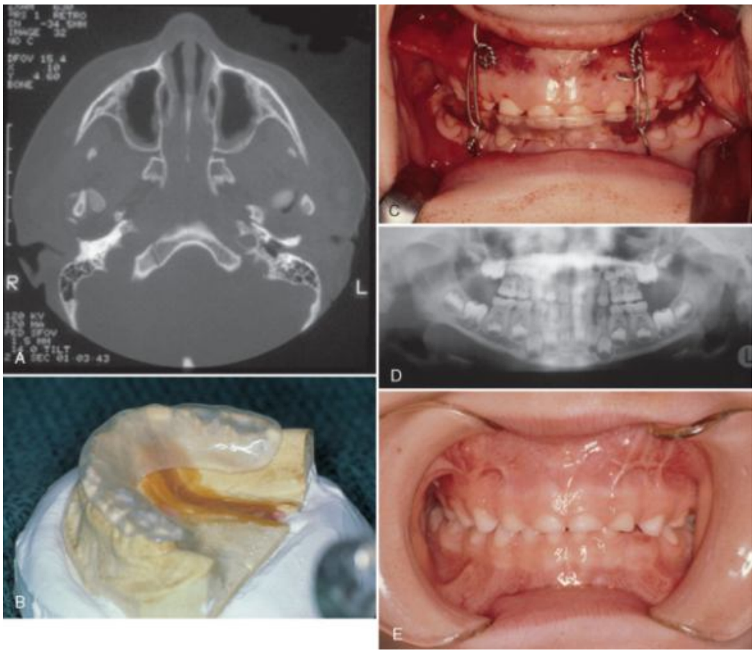

Figure 92-14 A 5-year-old patient was an unrestrained passenger in a motor vehicle accident. **A,** Non–contrast-enhanced axial computed tomography scan demonstrating multiple intracapsular fractures of the bilateral condyles. Additional lower cuts also revealed a right symphysis fracture through the developing permanent canine tooth bud. **B,** After nasally intubating the patient in the operating room, dental molds were taken and stone casts poured. The lower cast, seen here, was sectioned at the displaced fracture line of the right parasymphysis and reduced relative to the maxillary dentition. **C,** An acrylic splint was then fabricated to index these adjustments. The acrylic splint was inserted after placing bilateral 24-gauge skeletal wires at the piriforms and circum-mandibularly. Care was taken to not pass the right circum-mandibular wire within the fracture line of the right parasymphysis. The patient was maintained in skeletal and maxillomandibular fixation for 2 weeks. The intermediate 26-gauge wires were then cut and the patient allowed to function. **D,** A panoramic radiograph taken 2 weeks after removal of the skeletal suspension wires shows good maintenance of the entire dentition and no developing open bite. Both condyles are beginning to re-form. **E,** Occlusion 6 months after surgery showing vertical overlap and good interdigitation.

Multiple Fractures

With comminuted mandible fractures, I find it easier to piece together the larger, more stable fragments with miniplates and then consolidate and rigidly fixate the entire complex with a larger spanning fracture or reconstruction plate (Fig. 92-15). Locking screws that engage the plate itself help improve stability and minimize distraction of segments during screw tightening because it is virtually impossible to adapt the large plate in full passive contact with all the bony segments.

Figure 92-15 Twenty-four-year-old woman involved in a motor vehicle accident. **A,** Non–contrast-enhanced axial computed tomography (CT) scan showing comminution of the inferior border of the mandible. **B,** A panoramic radiograph obtained before the CT scan shows comminution of the right parasymphysis, a left body fracture, and a right condyle fracture with numerous craze lines. **C,** The patient had a large laceration of the chin and submental region that was extended 2 to 3 cm along the left mandibular angle region. First, monocortical miniplates and a locking screw system were used to piece the bony fragments together. The larger spanning rigid plate was then adapted to the inferior border and locking screws inserted. **D**, Postoperative panoramic radiograph showing maxillomandibular fixation, which was maintained for 2 weeks to treat the right condyle fracture in closed fashion. **E,** Three months' postoperative facial appearance. **F,** Submental view of the healed laceration. The patient declined to have any revision surgery for this. **G,** Left lateral view of the final occlusion.

When deciding whether to use an intraoral versus an extraoral approach for plating, the surgeon should take into consideration several factors. More posterior fracture locations, any comminution, and edentulous fractures are better suited to extraoral approaches.

Thin edentulous bilateral body fractures are best treated via an extraoral approach.[13] After the chin segment is dissected at the inferior extent of the mandibular border, a portion of the mentalis is stripped and a single bicortical screw is inserted in the midpoint of the chin with 3 to 4 mm exposed beneath the head. A large Kelly clamp is then used to grasp the screw shaft and retract anteriorly to make the tissue planes more identifiable and the posterior subperiosteal dissection easier. A long-span rigid plate with three to four screws in the symphysis and three to four screws in the angle provides more reliable rigid fixation and predictable healing without any secondary procedures (Fig. 92-16).

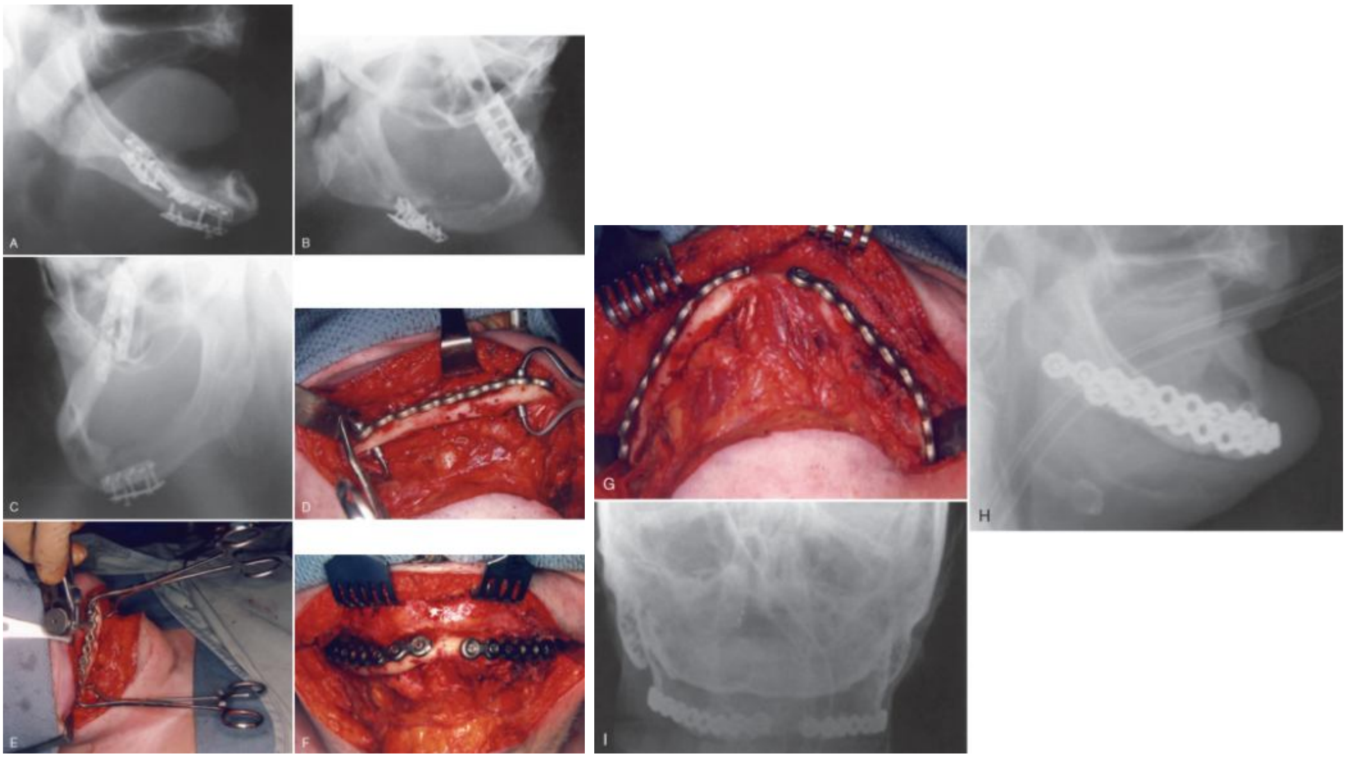

Figure 92-16 A 54-year-old institutionalized, mentally challenged man with spina bifida was referred for nonhealing and infection of bilateral edentulous body fractures. **A,** A lateral mandibular radiograph shows that the patient had previously undergone open reduction and internal fixation of the fractures and that miniplates had been applied to the lateral surface and the inferior border. The plates were fairly short in span and placed in an unfavorable compression zone, so during function the fracture would tend to gap superiorly. **B,** Right oblique view showing complete loss of fixation and osteolysis. **C,** Left oblique view demonstrating similar findings and screws backing out. **D,** The patient underwent wide extraoral exposure and débridement of the fibrous and granulation tissue on all bony margins. The right body fracture is seen reduced and a rigid reconstruction plate (2.3-mm system) was positioned and held with self-retaining clamps. **E,** A drill guide was used and locking screws inserted in the sound bone at least 4 to 5 mm away from the fracture site. **F,** Frontal view of the fully fixated mandible. **G,** Submental view. **H,** Postoperative lateral mandibular radiograph showing excellent projection and contours. **I,** Anteroposterior radiograph demonstrating symmetry and normal contours.

When treating comminuted or edentulous mandible fractures or when drilling at an angle to avoid vital structures, locking screw systems help prevent displacement of the segments and provide excellent rigidity. When drilling screw holes for these or any rigid plating systems (>2-mm external thread diameter, 1.5-mm burr), the drill guide should be used to properly align the bony hole within the plate hole and thus prevent deflection with screw tightening (see Fig. 92-16E).

POSTOPERATIVE MANAGEMENT

Patients treated by open reduction and plating of mandibular fractures should be placed on a soft diet that does not require chewing for several weeks and then advanced to a normal diet only after 6 weeks. Even then, tough foods such as raw carrots, bagels, and the like should be avoided for several more weeks.

If the fracture has been treated in closed fashion and the patient is in MMF, oral hygiene is especially important. The patient should be instructed to brush the teeth and arch bars daily and to perform oral saline rinses. Soft dental wax can be given to the patient to place over any sharp or prominent areas. Wire tails should be bent inward to minimize lip and cheek irritation. Wire cutters should be given to the patient at the bedside and on discharge from the hospital so that the MMF (the vertical wires) can be cut in the event of an airway emergency. Nutrition consultation should be considered for patients with planned periods of 4 to 6 weeks of MMF. The MMF and circumdental wires can be removed in the office under local anesthesia, sometimes supplemented with intravenous sedation. The MMF wires should be released first, before intravenous sedation, in case airway access or support is needed. Patients with open mandible fractures are usually placed on antibiotics at the time of diagnosis, through surgery, and for several postoperative doses. Prolonged antibiotic therapy or broad-spectrum antibiotics are not indicated and have not been shown to provide any benefit.

PEARLS

- Use drill guides with the more rigid plating systems to help prevent subtle shifting of segments.
- During application of rigid fixation, continuously recheck the occlusion to make sure that tightening of the last screw did not distract the bony segments.
- Mandible fractures in the pediatric age group are often best treated with closed techniques.
- Place the patient in maxillomandibular fixation before plating any fractures.
- Remove arch bars at the end of surgery unless they are necessary for postoperative interdental fixation or elastic guidance.

PITFALLS

- Lack of copious irrigation while drilling screw holes may result in overheated or necrotic bone that does little to stabilize fixation screws and can result in microscopic or gross mobility of the fixation and fracture before healing.
- If a tooth is left in the line of fracture or if the tooth itself is fractured or grossly decayed, it may limit bony reduction or result in a postoperative infection.
- Plates that are not placed perpendicular to the fracture line can cause vertical deflection during screw tightening and may be less stable.
- Mucosal incisions that are less than 1 cm away or close to the mucogingival junction do not allow suturing of the muscle layer, which is a risk for wound dehiscence and plate exposure.
- Intraoral approaches to condylar, subcondylar, and ramal fractures often result in a prolonged frustrating attempt at plating and lead to suboptimal alignment.