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MANDIBULAR FRACTURES

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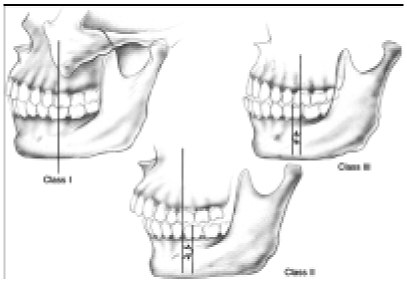
After the nose, the mandible is the second most commonly fractured facial bone. Mandibular fractures are probably the most common facial fracture necessitating treatment. Because of its position surrounding the salivary pool in the floor of the mouth and its intimate supporting function for half of the dentition, the complication and infection rates for mandibular fractures far exceed those of fractures of other facial bones (1).

ANATOMY

The mandible articulates with the skull base at the paired temporomandibular joints and is suspended by a complex masticatory neuromuscular apparatus. A complete bony ring is thus formed by the skull and mandible. This ringlike structure contributes to the tendency for fractures to occur at two separate sites as the result of trauma. Anatomic components of the mandible include the symphysis, parasymphysis, body, angle, ramus, coronoid process, condyle, and alveolus. Inherent sites of weakness include the third molar area (especially if the third molar is impacted), the socket of the canine tooth, and the condylar neck.

Knowledge of the occlusion is integral to the diagnosis and management of all facial fractures. In the Angle classification of occlusion the mesiobuccal cusp of the maxillary first molar is used as a reference (Fig. 65.1). Class I occlusion is the norm. Class II represents retrognathism, and Class III represents prognathism. Cognizance of the three classes of occlusion and careful examination of the teeth for wear facets and cuspal interdigitation allow accurate restoration of the patient's preinjury bite. The universal dental numbering system is useful in describing the location of mandibular fractures and reporting associated dental injuries (Fig. 65.2).

FIGURE 65.1. The Angle classification of occlusion is based on the relation of the mesiobuccal cusp of the maxillary first molar to the buccal groove of the



mandibular first molar.

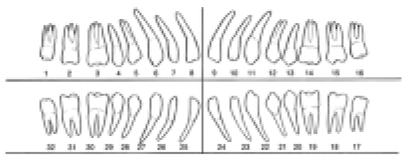


FIGURE 65.2. The universal numbering system for the permanent dentition begins with the maxillary right third molar. Similarly, the 20 teeth of the deciduous dentition are lettered from *A* to *T*, beginning with the maxillary right second deciduous molar.

Biomechanics of the Mandible

Mandibular fractures are described as *favorable* when muscles tend to draw the fragments toward each other and reduce the fracture and as *unfavorable* when the fragments tend to be distracted. Fractures can be vertically or horizontally favorable or unfavorable (Fig. 65.3). Almost all fractures of the angle are horizontally unfavorable. The masseter, medial pterygoid, and temporalis muscles contribute to displacement of the posterior segment. Vertically unfavorable fractures most often involve the body and symphysis-parasymphysis areas and are primarily distracted by the mylohyoid muscle. Closed reduction usually is limited to favorable fractures, but open reduction with rigid fixation techniques can be applied in either situation.

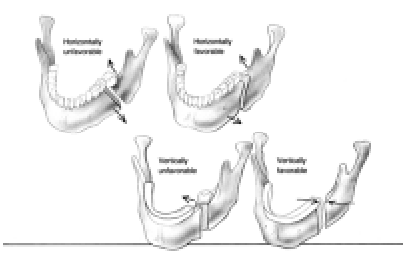


FIGURE 65.3. Horizontally unfavorable fracture of the angle shows displacement in a vertical direction owing to the action of the masticatory muscles. A vertically unfavorable body fracture is distracted horizontally by the mylohyoid bone.

Biomechanically the mandible can be considered a cantilever beam. The beam is suspended at two points, which represent the temporomandibular joint (TMJ) attachment. The muscles of mastication produce forces that act on this beam, and the teeth act as fulcrums. In the mandibular body and angle, forces produce zones of relative tension or distraction along the inferior border and compression along the superior border (2). In the symphyseal area, however, the situation is more complicated. Compression is produced at the upper border, and tension and torsional forces exist along the lower border (2). Tension and compression forces dictate the type of fixation applicable to a particular fracture.

EVALUATION AND DIAGNOSIS

History

Pain and malocclusion after a blow to the lower face strongly suggest mandibular fracture (Table 65.1). Additional symptoms include anesthesia of the lower lip and chin caused by trauma to the inferior alveolar nerve in its course through the mandibular canal.

TABLE 65.1. DIAGNOSIS MANDIBULAR FRACTURE

Malocclusion
Fragment mobility
Trismus
Deviation on opening toward side of fractured condyle
Anterior open bite contralateral to side of fractured condyle
Radiographic evidence of fracture
Possible hematoma in floor of mouth
Possible laceration of attached gingiva overlying fracture site
Possible anesthesia or paresthesia of lower lip and chin

TABLE 65.1. DIAGNOSIS MANDIBULAR FRACTURE

Physical Examination

Fractures of the symphysis-parasymphysis and body can be accompanied by hematoma in the floor of the mouth or laceration of the attached gingiva adjacent to the teeth. Mobility of fractures in these locations often can be identified by means of palpation. Trismus is a relatively constant finding with mandibular fractures, but it also occurs after facial contusions without fracture. The interincisal opening of a patient with a

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mandibular fracture usually measures 35 mm or less because of muscle splinting; the lower limit of normal is 40 mm.

Fractures of the condyle and condylar neck are associated with impaired translational movement of the condyle along the articular eminence. Although limited rotation can occur, this lack of translation produces a characteristic deviation of the chin on opening toward the side of such a fracture (Fig. 65.4). Fractures of the neck of the condyle tend to be displaced anteromedially in response to the action of the lateral pterygoid muscle. This displacement produces a loss in the functional height of the ramus, which allows premature contact of the ipsilateral molar teeth. The point of contact acts as a fulcrum and produces a characteristic open bite on the side opposite the fracture (Fig. 65.5). Bilaterally displaced fractures of the necks of the condyles produce a symmetric anterior open bite.

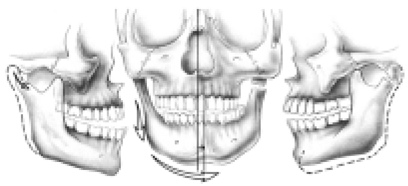

FIGURE 65.4. A fractured condyle does not translate down the articular eminence on jaw opening. The unopposed translational movement of the opposite condyle deviates the chin toward the side of the fractured condyle.

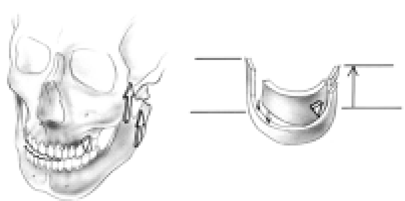

FIGURE 65.5. A fractured condyle usually is distracted anteromedially by the lateral pterygoid muscle. This produces a shortened functional height of the ramus as the masseter, medial pterygoid, and temporalis muscles draw the ramus closer to the skull base. The ipsilateral molar teeth act as a fulcrum to produce a slight contralateral anterior open bite.

Radiographic Evaluation

The single best radiograph for evaluation of mandibular fractures is the panoramic view (Fig. 65.6). A mandibular series of plain radiographs often provides additional information, especially about the neck of the condyle, ramus, and symphysis. Computed tomography is less reliable than radiography for identifying minimally displaced mandibular fractures.

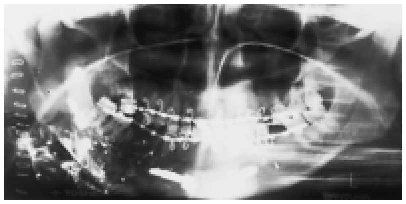

FIGURE 65.6. Panoramic radiograph of an avulsive mandibular fracture from a shotgun blast. Screws from the external fixation system are present.

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MANAGEMENT

General

Table 65.2 summarizes treatment options for adult patients. All fractures involving the tooth-bearing part of the mandible should be considered compounded into the mouth. These fractures necessitate antibiotic prophylaxis starting as soon as possible after the injury and ending when a watertight mucosal seal has been reestablished. Depending on the severity of the fracture, this can range from 24 hours to several weeks after reduction. Topical oral antiseptics also help minimize the bacterial inoculum of the fracture site. Although delay of fracture repair for several days does not seem to increase the complication rate, consideration of patient comfort warrants intervention as soon as possible. Marked displacement of the jaw fragments is uncomfortable for the patient, impairs oral hygiene and alimentation, and grossly soils the exposed bone with bacteria-laden saliva.

TABLE 65.2. TREATMENT OPTIONS FOR DENTATE ADULT PATIENTS

Structure	Closed Reduction	Open with Nonrigid Fixation	Open with Rigid Fixation	Observation Only
Condyle	+	-	Rare	Unilateral, nondisplaced with normal occlusion
Ramus	+	-	Rare	—
Angle	Favorable only		Inferior border compression plate plus tension band plate Tension band miniplate only Double miniplate Lag screw	—
Body	+	+	Compression plate plus tension band arch bar Lag screws plus tension band miniplate	—
Symphysis-parasymphysis	May require acrylic lingual splint	+	Lag screws Compression plate plus tension band arch bar	—

+, Treatment is generally applicable; -, treatment is generally not applicable. Unique situations and favorable operator experience with a specific technique may alter these guidelines.

TABLE 65.2. TREATMENT OPTIONS FOR DENTATE ADULT PATIENTS

Closed Reduction

Most favorable fractures in adult patients can be managed by means of closed reduction with arch bars or another means of interdental wiring. More than half of all mandibular fractures are amenable to closed reduction (3). Six weeks of intermaxillary fixation (IMF) usually is considered appropriate, although 4 weeks has been advocated (4).

Open Reduction

The classic indication for open reduction and internal fixation has been anticipated fragment displacement despite closed reduction. Many fractures can be approached transorally to avoid an external scar. Internal fixation can be classified as being rigid (reconstruction plates, compression plates, lag screws), semirigid (miniplates), or nonrigid (interosseous wires). Most rigid and some semirigid techniques obviate prolonged IMF.

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This is an especially important consideration among patients with epilepsy, diabetes, alcoholism, psychiatric disorders, or severe debility, who may not tolerate IMF. Rigid and semirigid internal fixation requires more hardware and greater cost. More extensive periosteal stripping and more manipulation of soft tissues are required. Because more holes have to be drilled, there is a higher incidence of nerve injury (5).

Compression plates and lag screws produce interfragmentary compression of bone, whereas the other techniques do not. The large dynamic compression or eccentric dynamic compression plates usually require an external approach. Damage to the facial nerve and soft-tissue scarring can result (6). Bending of plates is difficult with the system, and malocclusion rates up to 23% have been reported (6). Fractures that follow a fairly straight course from buccal to lingual cortices lend themselves easily to compression plate osteosynthesis, but sagittal or oblique fractures should not be subjected to axial compression (7). Sagittal and oblique fractures may be more amenable to repair with lag screw techniques. To achieve optimal compression without displacement, a lag screw hole is drilled along a line as close to perpendicular to the fracture line as possible. Compression is not used in cases of infection or comminution (8). In such instances, large reconstruction plates and 2.7-mm or 2.4-mm screws are considered. These plates ideally require placement of at least three screws in the peripheral fracture segments. Although reconstruction plates do not produce compression of the fracture segments, they do produce rigid fixation.

Symphysis-Parasymphysis Area

The lack of occlusal stops and locks in the anterior teeth produces special problems in the symphyseal and parasymphyseal region. Closed reduction is difficult in this area. Vertically unfavorable symphyseal fractures tend to collapse the mandibular arch in response to the mylohyoid muscle. To resist this scissors-like collapse, closed reduction techniques often include application of a custom acrylic lingual splint in addition to IMF. Open reduction with rigid internal fixation avoids both the splint and the need for IMF. The use of a rigid technique necessitates application of an arch bar and temporary intraoperative interdental wiring. The mandibular arch bar provides initial tension at the superior mandibular border.

Compression at the inferior border can be provided with a contoured reconstruction plate or several lag screws (9) (Fig. 65.7). Because vertically unfavorable fracture segments tend to telescope, use of bicortical compression plates to establish normal occlusion is particularly difficult in this region (10).

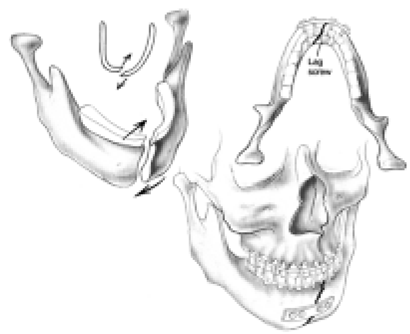

FIGURE 65.7. Initial tension compression at the superior mandibular border provided by the arch bar. The compression plate is slightly overbent and is applied with bicortical screws. Alignment of one screw through the fracture site can add lag screw compression.

Body

Transoral application of a compression plate to fractures posterior to the mental foramen is difficult, although semirigid techniques can be applied transorally in this area with greater ease. An eccentric dynamic compression plate can be applied through a large external incision with precompression of the fracture with a special pliers and the arch bar as a tension band. If the fracture is oblique or comminuted, use of a large reconstruction plate is an option, but a large external incision is necessary. Multiple lag screw fixation is a third alternative. Anterior body fractures coursing through the mental foramen can be managed by means of placing an inferior lag screw through a cutaneous stab incision and a monocortical miniplate tension band transorally above the mental foramen (Fig. 65.8). Either of the lag screw options offers enough rigidity to obviate IMF and avoid the large cervical scar associated with the external technique.

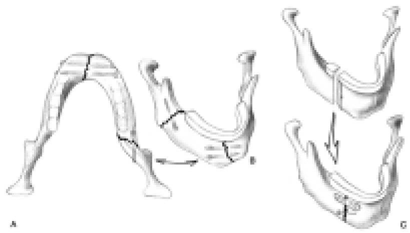

FIGURE 65.8. A, B: Double lag screws are placed in a fracture of the symphysis, and a single oblique lag screw is placed in the angle fracture. **C:** Body fracture through the mental foramen is managed with a miniplate and monocortical screws above the foramen and a single lag screw below.

Angle

Fractures of the angle are associated with the highest incidence of infection (11). The relatively small cross-section of bone in this region and the oblique and irregular fracture configurations make compression osteosynthesis particularly unfavorable (11). Transoral placement of a single tension-band miniplate (noncompression with monocortical screws 2.0 mm in diameter)

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near the superior border has been used as an alternative to interosseous wiring, although inferior border displacement with masticatory loading has been described (12). Applying a second miniplate to the buccal cortex has been shown to decrease the complication rate, even without the use of IMF (13). The external approach, with application of either a large eccentric dynamic compression plate or both a dynamic compression plate and a tension band miniplate, provides rigid fixation but requires a large external incision. The single oblique lag screw technique (14) provides solid fixation and avoids both IMF and a large external incision. Each of these techniques is effective; selection is based on the suitability of overlying lacerations, availability of equipment, and physician experience.

Ramus

Fractures of the ascending ramus are naturally splinted by the pterygomasseteric sling and are amenable to closed reduction. This splinting effect allows early release of IMF for nondisplaced fractures (3 to 4 weeks). Access to this area for plating, either transorally or extraorally, is somewhat difficult unless overlying lacerations are present.

Condyle and Condylar Neck

The indications for open reduction of condylar fractures remain debatable and have been summarized by Zide and Kent (15) (Table 65.3). Fractures in this area usually are managed by means of closed reduction, although an overlying laceration can facilitate application of a miniplate to the condylar neck. Fractures within the capsule of the TMJ are not opened and are managed by means of closed reduction.

TABLE 65.3. INDICATIONS FOR OPEN REDUCTION OF MANDIBULAR CONDYLE FRACTURES

Absolute indications
Displacement into the middle cranial fossa
Impossibility of obtaining adequate occlusion by means of closed reduction
Lateral extracapsular displacement of the condyle
Invasion by a foreign body (e.g., gunshot wound)
Relative indications
Bilateral condylar fractures in an edentulous patient when splinting is impossible
Unilateral or bilateral condylar fractures when splinting is not recommended for medical reasons or adequate postoperative physiotherapy is impossible
Bilateral condylar fractures associated with comminuted midfacial fractures
Bilateral condylar fractures associated with marked preinjury malocclusion

Adapted from ref. 15.

Exercise sessions every 2 weeks allow a brief release from IMF to avoid intra- and periarticular fibrosis and ankylosis. The duration of IMF varies with the severity of the condylar fracture. Nondisplaced fractures can be managed with 3 weeks of IMF followed by 2 weeks of night elastic-band fixation. Displaced fractures require 6 weeks of IMF, followed by several more weeks of night elastic fixation if a contralateral anterior open bite develops after release of fixation. Techniques with endoscopic approaches and instrumentation for fracture reduction and fixation have been described (16).

SPECIAL CONSIDERATIONS

Edentulous Fractures

The classic management of an edentulous mandibular fracture has been closed reduction in which arch bars are applied to the patient's dentures to allow IMF. If dentures are not available, Gunning splints can be fabricated. The dentures or Gunning splints are secured to the maxilla with circumzygomatic and anterior nasal spine wiring, Kirschner pinning through the alveolus, or screws into the palate. Fixation to the mandible is achieved with three circummandibular wires. The inherently poor hygiene of dentures or splints makes IMF extremely onerous for an edentulous patient, and rigid techniques often are used to manage edentulous fractures without advanced mandibular atrophy. Markedly atrophic mandibles tend to fracture at the weakest point in the midbody, where the diameter of the jaw can be that of a pencil (Fig. 65.9). Inadequate bone is present for rigid fixation, and nonunion is a frequent complication. Aggressive surgical management (sandwiching the fracture between split ribs and packing the site with autogenous iliac marrow) often is successful (17). However, many patients are elderly or debilitated, and the need for this major surgery must be balanced against the patient's medical condition.

FIGURE 65.9. The atrophic, edentulous mandible often fractures at the midbody, where the atrophy is most

advanced.

Treatment by Means of Observation Only

Some patients can be treated with a liquid to soft diet and careful follow-up evaluation. Such situations include a unilateral nondisplaced fracture of the condylar area in which patients can easily bite to their normal occlusion. If malocclusion is present after periarticular edema resolves, closed reduction is performed. Nonoperative management of condylar fractures can be used more liberally for edentulous patients, who can tolerate moderate degrees of condylar displacement. New dentures can compensate for the change in jaw relations.

Pediatric Fractures

Almost all fractures involving the deciduous dentition can be managed by means of closed reduction for 2 to 3 weeks. Rigid techniques place the developing tooth buds at risk and usually are avoided. The most dreaded complication of pediatric jaw fractures is the development of ankylosis of the TMJ, which can alter jaw growth and produce a severe facial deformity. Ankylosis is best avoided in the management of pediatric condylar fractures by allowing weekly mobilization of the jaw with a rapid return to normal jaw function.

The crest of the curvature of the crown of a deciduous tooth is closer to the gingival margin than is the crown of a permanent tooth, making placement of periodontal wire ligatures difficult but not impossible. Intermaxillary fixation can be established easily by means of direct skeletal wiring with 24-gauge wires passed

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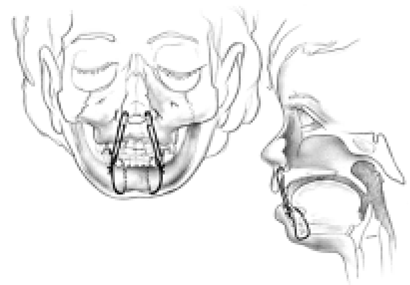
through holes drilled in the inferolateral margin of the piriform rim and wired directly to circummandibular wires (Fig. 65.10). Such skeletal wiring also helps reinforce arch bar fixation for adults whose anterior dentition is partially missing or unstable.

FIGURE 65.10. Arch bar application can be avoided in deciduous or mixed dentition by means of direct skeletal wiring from the piriform rims to circummandibular wires.



Management of Teeth in the Line of Fracture

It is generally agreed that teeth with fractured roots must be removed. Much controversy has arisen, however, regarding the retention of uninjured, stable teeth in the line of a mandibular fracture. Although each situation must be evaluated individually, most such teeth can be and are retained (18).

External Fixation

Stabilizing mandibular defects and fractures by means of external fixation is particularly applicable in contaminated gunshot wounds resulting in loss of part of the mandible (19)

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(Fig. 65.11). Although rigid fixation with implantation of a three-dimensional reconstruction plate can be used in this instance, external fixation provides the advantage of fragment stability with neither IMF nor a foreign body in the wound and allows access to the wound for subsequent débridement and hygiene.

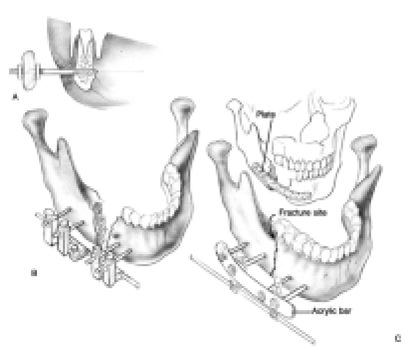

FIGURE 65.11. A: Percutaneous bicortical placement of the external fixator screw. **B:** Application of the primary-phase hardware allows precise alignment of the fracture or defect. **C:** The acrylic bar is applied and cured in the second phase, and the primary-phase hardware is removed.

Removal of Hardware

The need for hardware removal is controversial. Titanium, unlike the stainless steel used in older plates, forms an intimate association with bone that makes miniplate removal technically difficult and probably unnecessary.

COMPLICATIONS

Table 65.4 lists complications of mandibular fractures. The infection rate for mandibular fractures is about 10%, and the incidence of osteomyelitis is approximately 3% (20,21). Osteomyelitis can lead to nonunion, and subsequent bone grafting can be done after adequate resolution of infection. Infection does not seem to be consistently linked to transoral open reduction or retention of a tooth in the line of fracture (22,23).

TABLE 65.4. COMPLICATIONS MANDIBULAR FRACTURES

Infection
Malocclusion, malunion, nonunion
Temporomandibular joint ankylosis
Temporomandibular joint dysfunction
Sensory disturbances of inferior alveolar nerve

TABLE 65.4. COMPLICATIONS MANDIBULAR FRACTURES

In one study, a 1.1% rate of malocclusion was found among patients treated with rigid techniques (24). Marked malocclusion immediately after rigid fixation is probably caused by an error in fragment alignment and is permanent unless corrected by means of prompt revision surgery. Standard orthognathic surgical techniques can be used to correct malocclusion due to malunion of jaw fractures. Although posttraumatic TMJ ankylosis is rare, the true incidence of TMJ dysfunction after mandibular fracture is difficult to establish because of the subjective nature of the assessment and the prolonged time that often elapses before an internal joint injury manifests itself. Sensory disturbances of the inferior alveolar nerve are common after mandibular fracture, but traumatic neuroma formation is rare.

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EMERGENCIES

Emergencies related to mandibular fractures are listed in Table 65.5. Bilateral fractures of the mandibular body can cause posterior displacement of the anterior mandibular arch owing to the presence of the suprahyoid musculature. This can necessitate precipitous airway impairment, especially when the patient is in the supine position. Immediate intervention is needed by placing the patient in the lateral decubitus position and temporarily wiring the teeth together or by means of establishing an airway by means of intubation or tracheotomy. Cerebrospinal otorrhea can herald displacement of a condylar head into the middle cranial fossa. Such an injury can be associated with a dural tear; neurosurgical consultation and prompt open reduction are appropriate. Concomitant injury to the adjacent internal carotid artery occasionally occurs in conjunction with fractures of the condylar neck. The presence of a severely displaced fracture can prompt further investigation into the integrity of the adjacent carotid artery. Gross hemorrhage rarely accompanies mandibular fracture, but troublesome bleeding occasionally arises from the inferior alveolar artery within the mandibular canal. Ligation of this vessel is difficult, and temporary reduction of the fracture effectively tamponades the bleeding site.

TABLE 65.5. EMERGENCIES MANDIBULAR FRACTURES

Airway obstruction
Condylar displacement into middle cranial fossa
Adjacent injury to internal carotid artery
Hemorrhage

FUTURE CONSIDERATIONS

The surging popularity of rigid fixation to manage mandibular fractures has left unanswered questions about the advisability and timing of the removal of fixation hardware. Concerns over stress shielding and possible delayed infection in the mandible cannot be addressed by inference from orthopedic data. Endoscopic approaches can reduce the morbidity associated with repair of mandibular fractures. Results of research on the efficacy of resorbable rigid fixation materials may provide head and neck surgeons with the ideal mandibular fracture fixation device.

HIGHLIGHTS

- The chin deviates when opened toward the side of a fractured condyle.
- Almost all condylar fractures are managed by means of closed reduction.
- Fractures of the condylar neck are associated with anteromedial displacement of the condyle owing to the action of the lateral pterygoid muscle.
- Almost all fractures of the mandibular angle are unfavorable and necessitate open reduction.
- When evaluating a mandibular or TMJ injury, it is helpful to measure the maximum interincisal opening; the lower limit of normal is 40 mm.
- Bilaterally displaced fractures of the condyles are associated with a symmetric anterior open bite.
- In almost all cases, teeth in the line of a mandibular fracture are preserved.

- Among children, posttraumatic ankylosis of condylar fractures produces severe developmental facial asymmetry.
- Bilateral fractures of the mandibular body, especially in edentulous patients, can allow the anterior arch of the mandible to fall posteriorly and obstruct the airway.
- When malocclusion is detected immediately after open reduction with rigid fixation, revision surgery usually is needed to correct the error in fragment alignment.

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