

Fractures of the Mandible

52

Anshul Rai

52.1 Definition

A fracture is defined as “A breach in the continuity of bone.”

52.2 Introduction

The mandible which is the only mobile bone of the maxillofacial region forms the lower third of the face. Owing to the prominence of the symphysis of the mandible, it is most vulnerable site to be traumatized during the road traffic accidents and, at the same time, most tempting site to be hit during the assault. Thus, the fractures of the mandible are one of the most common in maxillofacial area. It also affects the social life of the patients (Box 52.1).

The word “mandible” derives from the Latin word mandere “to chew” and -bula (instrument) which literally translates to mandibulae “instrument used for chewing.”

The bone is formed in the fetus from a fusion of the left and right mandibular prominences and the point where these sides join, the mandibular symphysis. Like other symphysis in the body, this is a midline articulation where the bones are joined by fibrocartilage, but this articulation fuses together in early childhood.

Box 52.1: General Effect of Mandible Fracture on Social Life [1]

1. Absence from work.
2. Hospital and ICU stay results in separation from family members and friends.
3. Financial loss.
4. Difficulty in feeding.
5. Weight loss (average 5% of total body weight).
6. Increased mental stress.
7. Delayed recovery in medically compromised and mentally challenged patients.

52.3 Surgical Anatomy

The mandible is a horseshoe-shaped only mobile bone of the facial skeleton. It is the strongest bone with thick cortices. Symphysis is the most prominent part of mandible, and the condyles articulate with glenoid fossa of temporal bone. The inferior alveolar neurovascular bundle passes through the bone, and in the case of fracture, it may get traumatized and can lead to hematoma and neurological deficit.

52.3.1 Angle of the Mandible

By definition, there are three types of angle as described below:

1. **Clinical angle:** It is the junction between the alveolar bone and ramus at the origin of internal oblique ridge.
2. **Surgical angle:** It is the junction between body of the mandible and ramus at the origin of the external oblique ridge.
3. **Anatomical angle or (gonion):** It is the junction where the lower border meets the posterior border of ramus.

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Anatomically, mandibular angle is a weaker structure compared to other anatomic subsites.

- The ramus of the mandible is thin as compared to the body. Whenever a thick portion of the bone unites with the thin portion, it constitutes a line of weakness.
- Further the third molars are located in the angle region, and when they are impacted, they occupy lot of space in the bone and undermine it.
- In the case of mesio-angular impaction, the impacted third molar tooth acts as a wedge and predisposes the fracture of angle of mandible, if the direction of force is perpendicular to it.
- The bone grains which are oriented vertically in the ramus change their course at the angle of mandible as they enter the body of mandible. This abrupt change in the course of the bone grains also makes the bone weak. All these factors make the mandible vulnerable for fracture at this site.

52.3.2 Canine Region of the Mandible

In the canine area, also the mandible is weaker as the canine has the longest and the strongest root, and it occupies lot of space in the bone and undermines and weakens it. Thus, the mandible has a tendency to fracture at this site.

52.3.3 Symphysis and Parasymphysis of Mandible

- The symphyseal area is most prominent and most vulnerable to trauma. There is a compression of the outer cortex and expansion of the inner cortex, and the fracture will result when the forces are beyond the limits of the capacity of the bone to withstand them.
- There is a pair of genial tubercles on the lingual cortical plate in the midline, situated supero-inferiorly, which give origin to the genioglossus and geniohyoid muscles, respectively. Whenever there is a bilateral fracture at the parasymphysis area, the tongue tends to lose its anchorage on the bone, and the patient loses control and the tongue tends to fall back. It is especially true for the unconscious patient, where the tongue fall blocks the airway, and it could be fatal if not prevented.

52.4 Classification

The general classification of fractures of bone is described in Table 52.1.

Table 52.1 General classification of fracture of bone

Simple fracture	This type of fracture is not exposed to the external environment as the overlying soft tissue cover is intact
Compound fracture	In such type of fractures, the fracture line is exposed to the external environment. All dentate fractures are compound fracture as they communicate with the oral cavity
Comminuted fracture	Comminuted fractures have multiple fracture lines and more than two bony fragments
Simple comminuted fracture	It is a comminuted fracture not exposed to the external environment
Compound comminuted fracture	This type of fracture is a comminuted one which is exposed to the external environment
Complicated fracture	This fracture involves vital structures like adjacent nerves, vessels, or joint, directly or indirectly
Impacted fracture	The fractured fragments inter-digitate to an extent that there is no appreciable clinical movement. Such a fracture is unusual in the mandible and is commonly seen in the maxilla
Greenstick fracture	It is an incomplete fracture presenting as cortical bending rather than breaking. It is commonly seen in children as their bones are more elastic in nature. This elasticity allows the bone to bend. This type of fracture is commonly seen in long bones and mandibular condyle of children
Pathological fracture	This fracture occurs readily with minimal trauma or sometimes even during normal physiological function as the bone is significantly weak due to existing undermining pathology

52.4.1 Classification of Mandibular Fracture According to Site (Fig. 52.1)

Figure 52.1 highlights the mandibular fracture according to site of fracture with its incidence [2].

52.4.2 Classification of Mandibular Fracture According to the Impact

According to the impact on bone, fracture can be classified as direct fracture and indirect fracture.

During an impact, the force on the cortex results in compression, and the other cortex undergoes tension. If the force of the impact is more than the compressive and tensile strength of the bone, the bone fractures.

In a similar fashion, when there is an impact, the point of application of force gets compressed, and the resultant vector travels along the bone and applies tensor force on the point intersected by this vector. The fracture at the site of impact is called **direct fracture**, and the fracture at the site of intersection with the vector is **indirect fracture**.

For instance, the force applied to the symphysis menti results in a direct fracture at the symphysis. The vector travels to the condylar necks bilaterally and induce indirect fractures

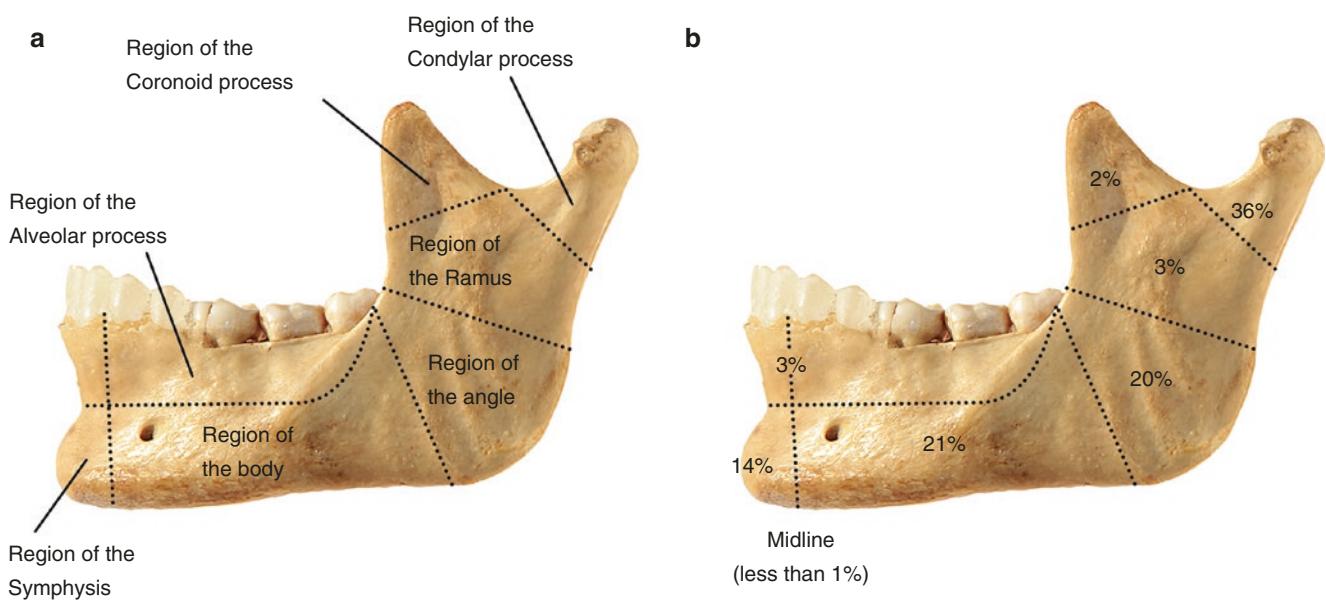


Fig. 52.1 (a, b) Highlights the mandibular fracture according to site of fracture with its incidence



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Fig. 52.2 3D CT showing parasympysis and bilateral condyle fracture

Table 52.2 Combination of mandibular fractures

Direct fracture	Indirect fracture
Symphysis fracture	Bilateral subcondylar fracture
Parasymphysis fracture	Contralateral subcondylar fracture
Body fracture	Contralateral angle fracture

of subcondylar areas bilaterally, as the condylar necks are weak. This is called a “tripod fracture” (as the fracture is at 3 points) or “parade ground fracture” or “guardsman’s fracture.” The later terms are used because these fractures are commonly seen among soldiers who stand upright on the parade ground for a long time. When they faint, they fall on their chin resulting in symphysis and bilateral condylar neck fractures.

52.4.3 Combination of Fracture

The most common mandibular fracture seen in the developed countries is angle fracture combined with contralateral body or symphysis of the mandible [3]. Table 52.2 and Figs. 52.2, 52.3, and 52.4 highlight various combinations of direct and indirect fractures in the mandible.

52.4.4 Classification of Mandibular Fracture According to Displacement

The fracture fragments are liable to displacement according to unfavorable muscle pull leading to difficulty in the management of these displaced fractures. Table 52.3 highlights various muscles attached to the mandible with their actions.

According to the displacement of fracture fragments due to muscle pull, the fracture can be classified as:

When viewed from superior aspect:

1. Vertically favorable: When the fracture line is passing from buccal cortical plate to the lingual cortical plate with the buccal end lying mesially and the lingual end of the line lying distally. In such situation the distal fragment will be drawn closer to the proximal fragment due to the pull of the medial pterygoid muscle, and the fracture segments will come closer rather than getting separated in buccolingual plane, and thus the fracture is called as vertically favorable (Fig. 52.5a).
2. Vertically unfavorable: In this case, the fracture line passes buccolingually with the buccal end lying mesially. The distal fragment in this case will be easily viewed from superior border. The distal fragment in this case will easily get drifted



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Fig. 52.3 Showing right parasymphysis and left condyle fracture



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Fig. 52.4 Showing right body and left angle fracture

lingually due to the pull of the medial pterygoid muscle; thus there will be separation of the fragments in the buccolingual plane due to the unfavorable muscle pull, and the fracture is said to be vertically unfavorable (Fig. 52.5b).

When viewed from buccal aspect:

1. Horizontally favorable: The fracture line runs supero-inferiorly with its superior end lying posteriorly than its inferior end. In this situation, the muscle pulls from the temporalis, masseter muscle will pull the distal segment superiorly, and the suprathyroid muscles will put the proximal segment inferiorly, thus drawing both the segments closer to each other. This type of fracture is called as horizontally favorable fracture (Fig. 52.6a).
2. Horizontally unfavorable: The fracture line runs supero-inferiorly with its superior end lying anteriorly and the inferior end lying posteriorly; thus, the muscle pull becomes unfavorable and drifts the proximal and distal fracture segments apart. This is described as a horizontally unfavorable fracture (Fig. 52.6b).

Table 52.3 Muscle attachments over the mandible with their actions

Muscle	Action	Attachment
Masseter-medial pterygoid	Elevators of the mandible	Ramus of the mandible
Temporalis	Elevators of the mandible	Coronoid process of mandible
Lateral pterygoid	Depressors of the mandible, lateral movements	Pterygoid fovea
Suprathyroid muscles (digastric, geniohyoid, mylohyoid)	Depressors of the mandible	Body and the genial tubercles

52.5 Clinical Features

The clinical features of the fractures are described in Table 52.4 (Figs. 52.7, 52.8, 52.9, 52.10, 52.11, 52.12, 52.13, and 52.14).

52.6 Clinical Examination

52.6.1 Bimanual Palpation

The abnormal mobility at the fracture site can be elicited by the bimanual palpation. The mandible is grasped on either side of the suspected fracture line in such a way that the index finger is on the occlusal surface of the teeth and the thumbs are on the inferior border. The proximal and distal segments are moved in supero-inferior and antero-posterior direction, to elicit abnormal mobility (Fig. 52.15).

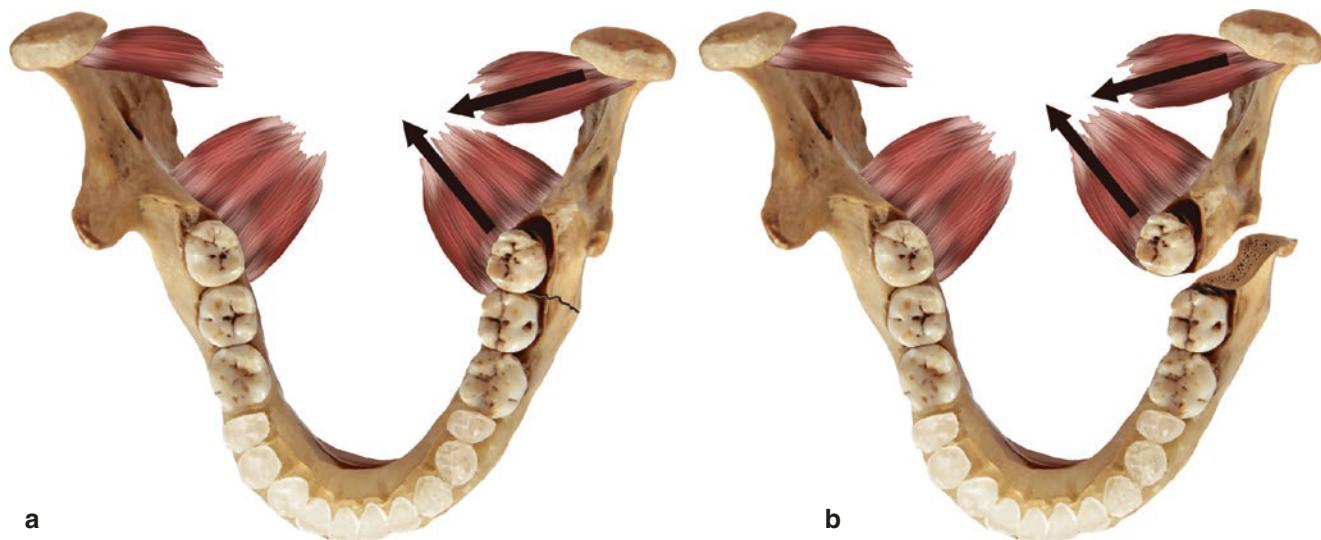
52.6.2 Compression Test

When there is a hairline, undisplaced fracture of the mandible especially at the symphysis or angle or in the subcondylar areas and it is not conspicuous clinically and radiologically, a compression of the mandible at the symphysis area and both the sides over the body, using both the palms by the operator, elicits tenderness which may suggest the fracture (Fig. 52.16a, b).

52.7 Radiographic Examination

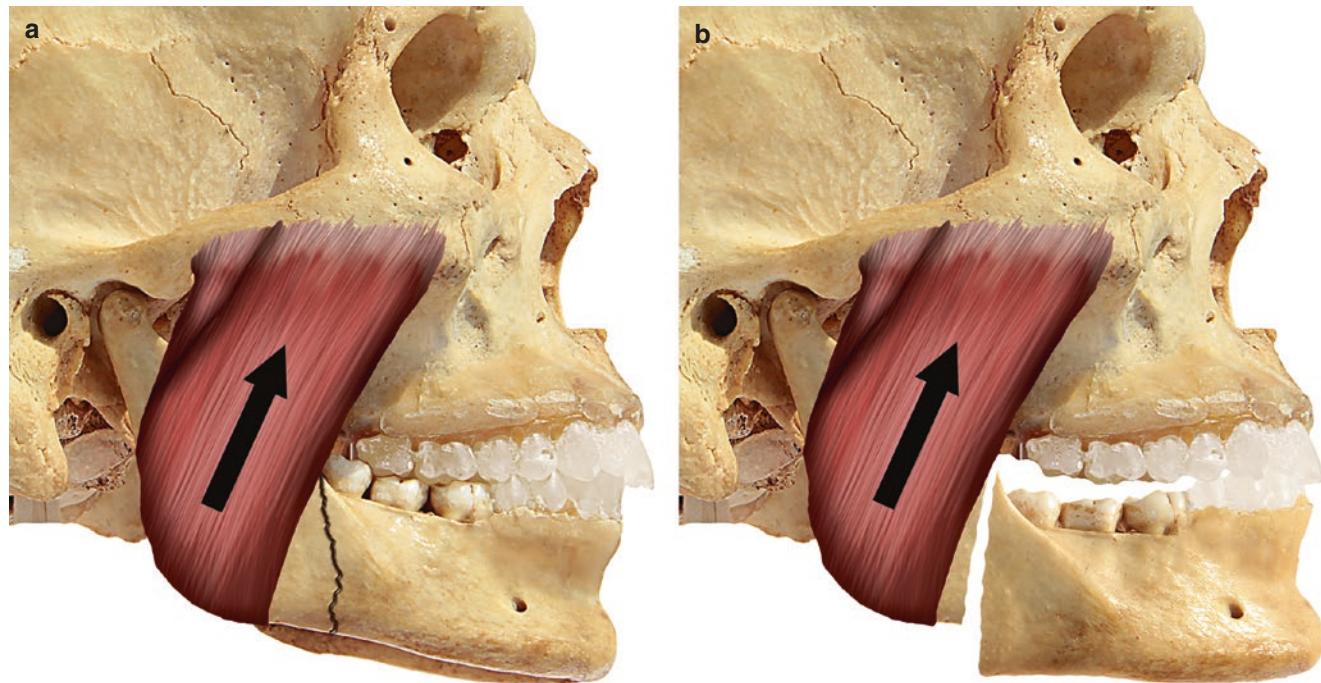
As a rule, in orthopedics, the X-ray must be taken in two planes perpendicular to each other, i.e., in the anteroposterior and mediolateral. The most common radiographs to detect fracture of the mandible are:

1. Orthopantomogram (OPG) (Fig. 52.17)
2. Postero-anterior view of the mandible (PA mandible) (Fig. 52.18)
3. Lateral oblique view is taken for body, angle, ramus, and subcondylar fractures.



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Fig. 52.5 (a) Vertically favorable. (b) Vertically unfavorable



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Fig. 52.6 (a) Horizontally favorable. (b) Horizontally unfavorable

- 4. Computed tomography (CT) scan (Fig. 52.19)
- 5. Digital visual tomography (DVT) (Fig. 52.20)
- 6. Cone beam computed tomography (CBCT) (Fig. 52.21)
- CT, DVT, and CBCT are the most commonly performed radiographs for the accurate diagnosis of mandibular fracture.

- Radiographs should not be advised unnecessary, and they should always be performed after clinical examination and after making provisional clinical diagnosis.
- Surgeons should not depend on the radiologist's report for their diagnosis; radiographs should help in confirming the clinical diagnosis and for the medicolegal record-keeping purpose as much as possible.

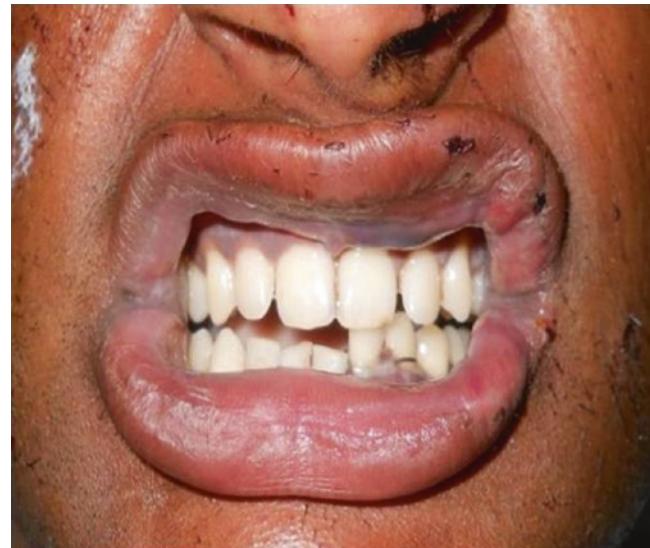
Table 52.4 Clinical feature of mandibular fracture

General symptoms	Signs on inspection	Signs on palpation
Pain	Presence of hematoma (Fig. 52.9)	Crepitus over fracture site
Swelling (Fig. 52.7)	Facial asymmetry	Abnormal mobility across fracture site
Difficulty in opening mouth (Fig. 52.8)	Presence of abrasion, contusion, or laceration (Fig. 52.10)	Fracture/mobility/extrusion/intrusion/avulsion of teeth
Tenderness over fracture site	Discoloration of the skin/echymosis (Fig. 52.11)	Tenderness over fracture site
Inability to chew	Trismus due to protective myo-spasm	Intersegmental mobility on bimanual palpation
Inability to swallow	Limited excursive movements of mandible	Positive compression test
Bleeding from the ear/mouth	Visible step deformity in cases with displacement of fractured segments (Fig. 52.12)	
	Malocclusion (Fig. 52.13)	
	Sublingual hematoma (Fig. 52.14) Coleman's sign	
	Tongue fall back in bilateral anterior mandible fracture	



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Fig. 52.7 Swelling in angle region after fracture



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Fig. 52.8 Difficulty in mouth opening due to displacement and deviation of fracture

52.7.1 Are Postoperative Radiographs Necessary?

The answer is no. The reasons behind this is:

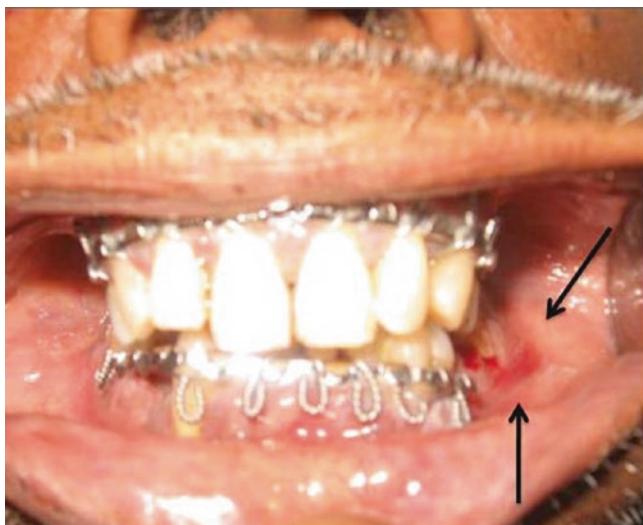
1. More than 100–250 deaths occur worldwide from cancer due to unnecessary radiation from diagnostic radiology as suggested by Royal College of Radiologists [4]
2. If somehow retreatment is required for the patient, it generally depends most commonly on the clinical findings rather than radiographic

However, the postoperative radiographs are required in few cases of:

- Mandibular fracture treated with closed reduction
- In medicolegal cases to prevent judicial complications [5]
- Patients who enrolled in the research activities

Bergh van den et al. [6] also suggested that postoperative radiography is not necessary. The advantages of avoiding postoperative radiographs are:

1. Exposure reduction of patients to ionizing radiation
2. Reduced cost
3. More efficient discharge



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Fig. 52.9 Hematoma in the angle region



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Fig. 52.11 Discoloration of skin



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Fig. 52.10 Presence of abrasion, contusion, or laceration



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Fig. 52.12 Visible step deformity in cases with displacement of fractured segments



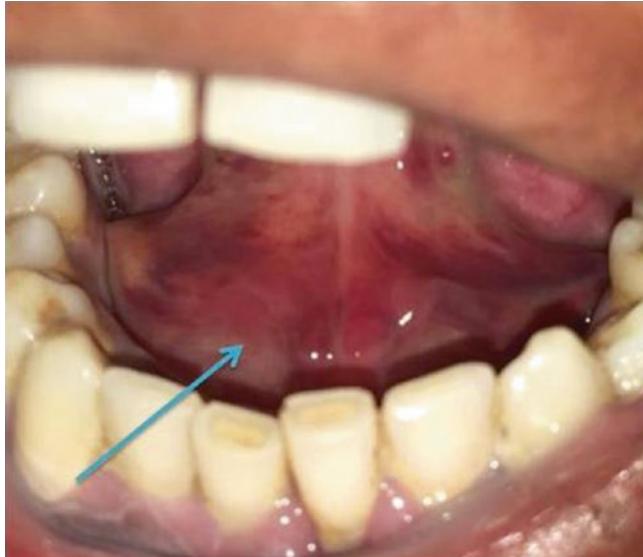
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Fig. 52.13 Malocclusion



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Fig. 52.15 Bimanual palpation



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Fig. 52.14 Sublingual hematoma (Coleman's sign)



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Fig. 52.16 (a, b) Vertical and horizontal compression test



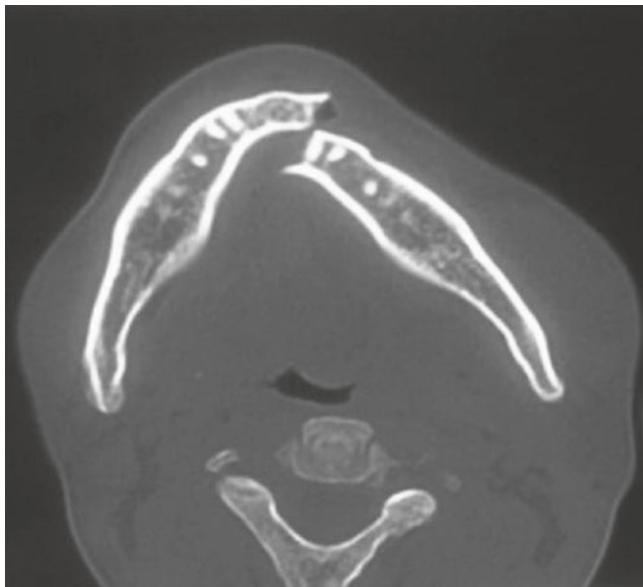
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Fig. 52.17 OPG demonstrating parasymphysis and contralateral condylar fracture



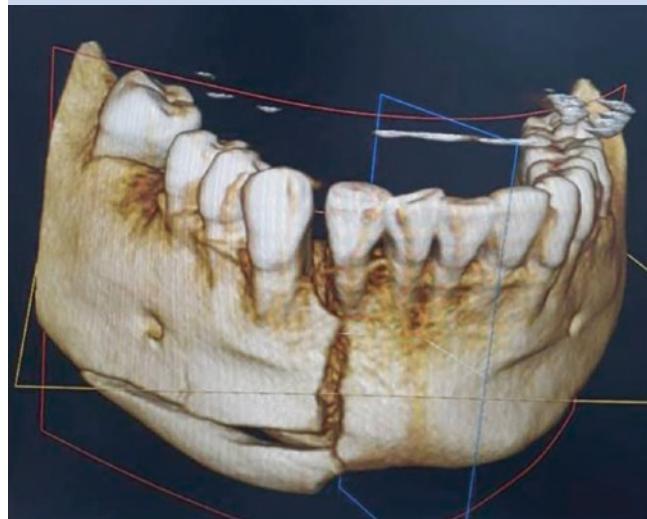
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Fig. 52.18 PA view mandible showing left mandibular angle fracture



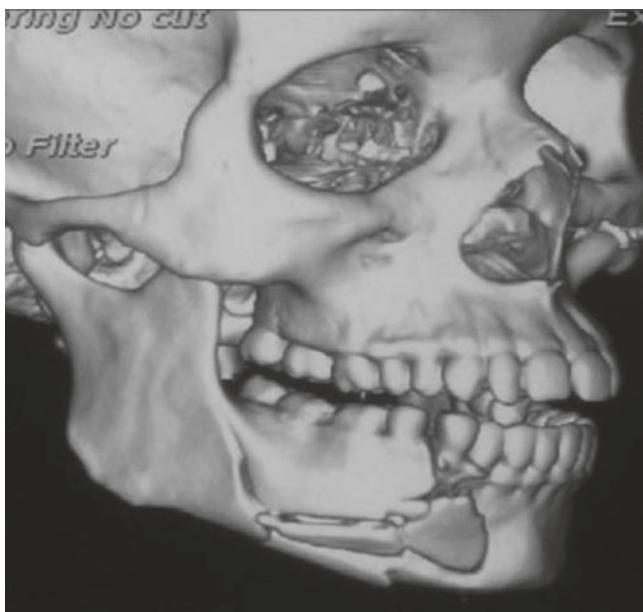
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Fig. 52.19 Computed tomography (CT) scan demonstrating displaced left para median fracture



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Fig. 52.21 Cone beam computed tomography (CBCT) demonstrating displaced right para median fracture mandible



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Fig. 52.20 Digital visual tomography (DVT) demonstrating comminuted right body fracture

52.8 Emergency Management (refer Chap. 48 of this book)

Once the basic Airway, breathing, circulation (ABC) in the emergency management has been secured, the suturing of the extra-/intraoral wounds and initial stabilization and immobilization of the fracture fragments are important. Box 52.2 shows advantages of immobilization of fracture fragments.

Initial stabilization and immobilization is done by:

1. Bridle wiring (refer Chap. 50 of this book)

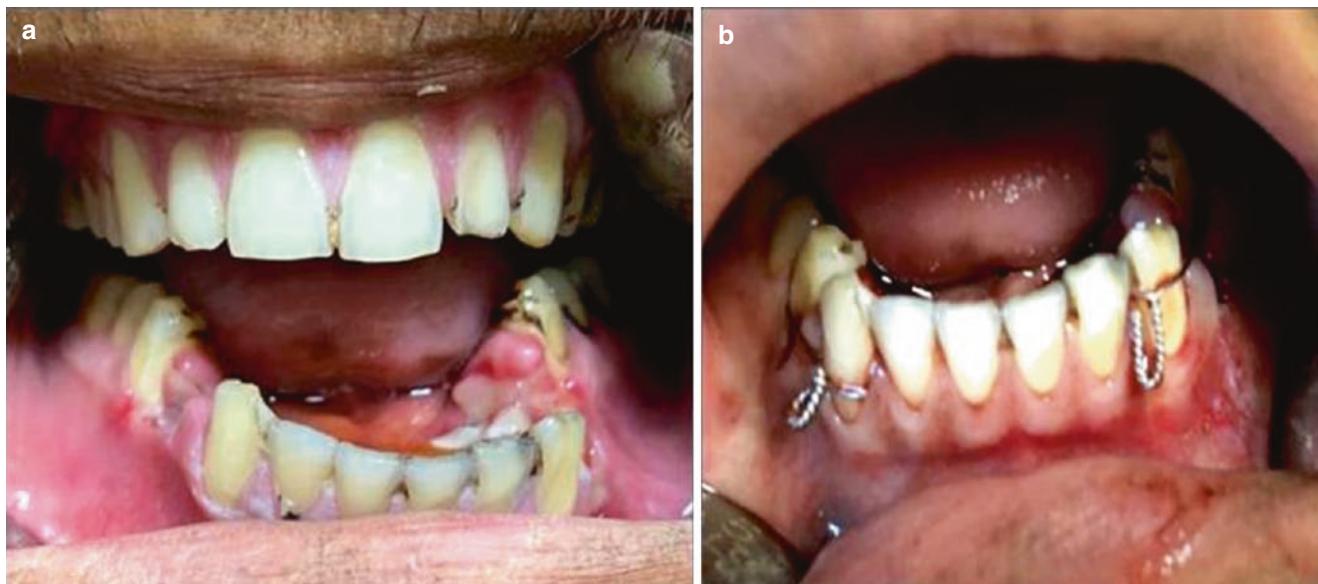
It is a type of temporary stabilization and reduction of the fracture fragments of the dentate segment with the help of 24- or 26-gauge wires under local anesthesia.

The wire should be wrapped around two healthy teeth adjacent to the fracture line; if the tooth adjacent to the fracture are mobile, the wire should be wrapped around the second tooth adjacent to the fracture (Fig. 52.22a, b).

2. Supportive bandage

These bandages are commonly used to temporarily stabilize the fracture of the lower jaw. Small crepe bandages can be used for mandible fracture.

- (a) Barrel bandage (Fig. 52.23)
- (b) Four-tailed bandage (Fig. 52.24)



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Fig. 52.22 (a, b) Temporary stabilization of a grossly displaced bilateral body fracture by bridle wiring



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Fig. 52.23 Barrel bandage



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Fig. 52.24 Four-tailed bandage

52.9 Goals of Treatment of Mandibular Fracture (Table 52.5)

52.10 Treatment Options for Different Sites

52.10.1 Closed Reduction (Table 52.6)

52.10.2 Clinical Tip

Wiring techniques required use of multiple wires. These wires cause inadvertent finger puncture to the operator's fingers and increases the risk of spread of blood-borne diseases like HIV and hepatitis. To avoid such complication, Rai [7] recommended the use of dynaplast adhesive tape over all fingertips before wearing sterile gloves while doing Maxillomandibular Fixation (MMF) (Fig. 52.25).

52.10.3 Open Reduction (Table 52.7)

52.10.4 Steps in Open Reduction Internal Fixation (ORIF) of Mandible Fracture

1. Incision (extra-/intraoral) (Fig. 52.26a, b).

Table 52.5 Treatment goals for mandibular fracture

1.	Anatomical restitution
2.	Immobilization
3.	Prevention of postoperative complications
4.	Rehabilitation of Functions

Table 52.6 Advantages and disadvantages of closed reduction

Advantages	Disadvantages
1. Day-care procedure, not require hospitalization	1. Restriction of mouth opening for minimum of 4 weeks
2. Cost-effective and safe	2. Patients can take only liquid diet
3. Avoid damage to the vital structures	3. Difficult to maintain oral hygiene
	4. Challenging in partially edentulous patients
	5. Weight loss
	6. Partial trismus for few weeks
	7. Contraindicated in asthmatic, in parkinsonism, mentally challenged patients

Table 52.7 Advantages and disadvantages of open reduction

Advantages	Disadvantages
1. Early return to function	1. Requires hospitalization
2. Exact anatomic reduction under direct visualization	2. Risk of general anesthesia
3. No need of MMF in most of the cases	3. Extra oral scarring
4. Less chances of postoperative complications	4. Risk of injuries to the vital structures
	5. Expensive to patients when compared to closed reduction



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Fig. 52.25 Finger protection before wiring

2. Exposure of the fracture site (Fig. 52.27).
3. Curettage to remove the granulation tissues and irrigation with normal saline.
4. Reduction of the fracture (with the help of bone-holding forceps) (Fig. 52.28a–c). Chin retractor is also helpful in reduction of fracture fragments (Fig. 52.29a, b).
5. Immobilization with MMF.
6. Fixation with plates and screws.
7. Closure of the incised site.
8. Pressure bandage over the surgical site to avoid postoperative hematoma formation in required cases (Fig. 52.30).

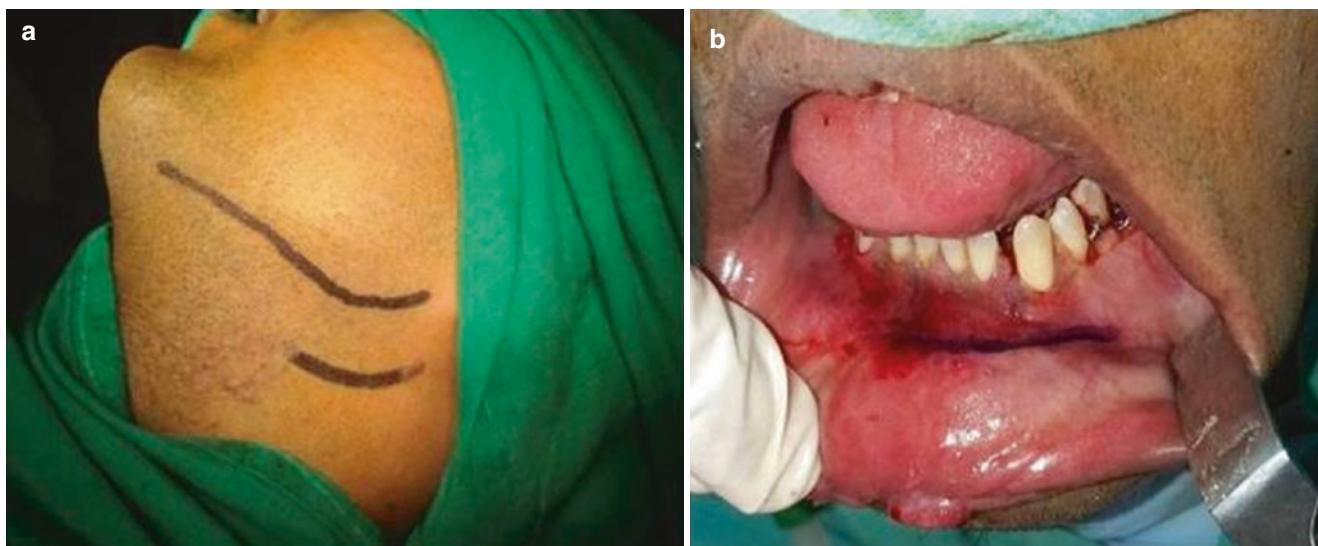
According to Dimitroulis [8] MMF is unnecessary in undisplaced angle fracture if there is a skilled assistant present to assist and help manually reduce the fracture fragments for plating. Author also believes that many undisplaced, single fracture of mandible can be fixed without MMF when two skilled surgeons operate the case.

52.10.5 Symphysis and Parasymphysis Fracture (Video 52.1)

Various internal fixation techniques were mentioned in the literature for both symphysis and parasymphysis fractures [9]. They are enumerated in Table 52.8.

Note: Readers has to refer Chap. 51 on plating systems to know the principles of osteosynthesis, tension banding, zone of compression/tension, etc.

Fixation with two miniplates is widely used for the fixation of symphysis and parasymphysis fractures (Fig. 52.31). Some authors preferred use of two lag screws (Fig. 52.32a, b) for the fixation of symphysis fractures, but their uses are less in comparison to two miniplates because they are technique sensitive. Three-dimensional plates require less manipulation and adaptation which indirectly reduce the operating time



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Fig. 52.26 (a, b) Extraoral sub mandibular incision and intraoral vestibular incision



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Fig. 52.27 Exposure of the fracture site (left paramedian mandible via vestibular incision)

(Fig. 52.33), but use of it is questionable when fracture fragments are multiple even in isolated symphysis fractures.

Usually, an intraoral approach is preferred for management of symphysis and parasympysis fractures. However, if an existing laceration or scar is present, it should be utilized for exposure of fractured segments and subsequent management (Fig. 52.34).

52.10.6 Parasympysis Fracture

1. Mental nerve: The anatomic challenge in ORIF.
2. Plating should be done after the blunt dissection and retraction of the neurovascular bundle.

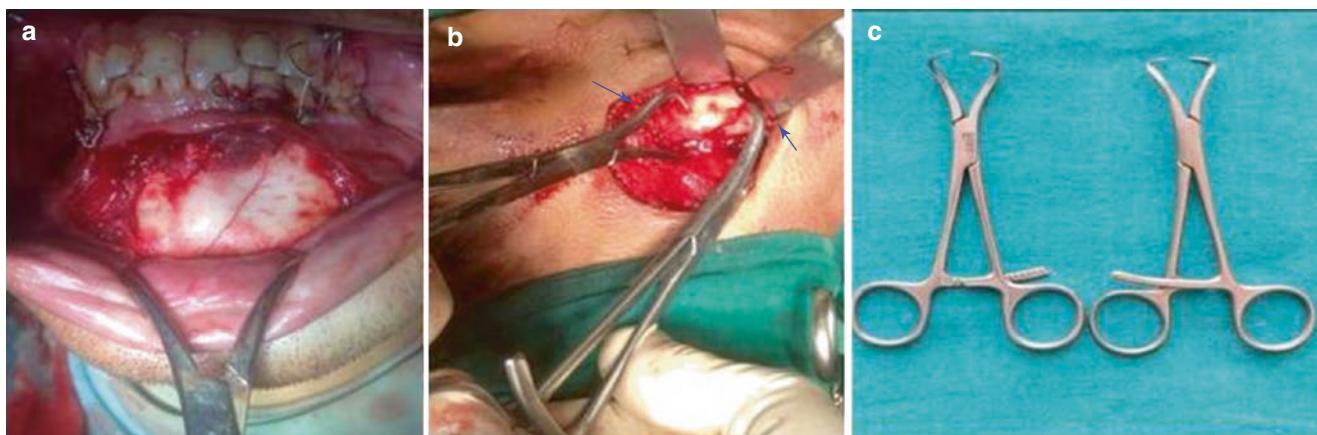
3. One miniplate above and another below the mental nerve used for fixation of parasympysis fracture (Fig. 52.35).

52.10.7 Mandibular Angle

The prevalence of angle fractures ranges from 16.5 to 37 % in the literature. Presence of third molar (3M) increases the chance of angle fracture by 3.27 times, and class II-B positions of 3M are the most favorable for angle fracture, while class I-A act as protective factors [10].

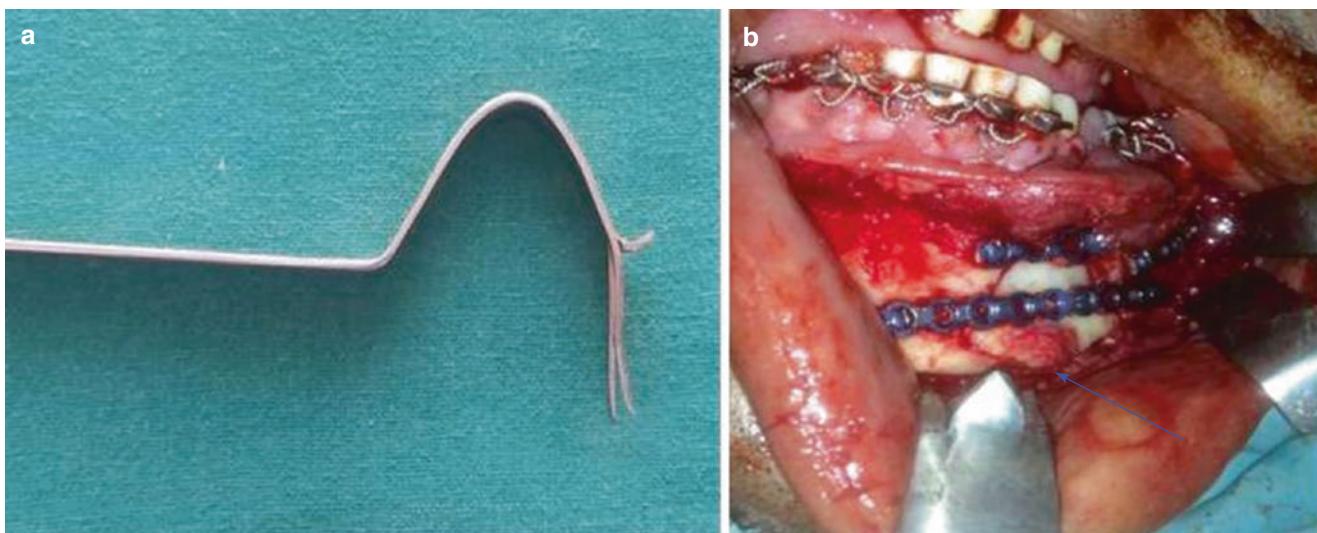
52.10.7.1 Impact of Presence or Absence of Impacted Mandibular Third Molar (IM3M) on Angle and Condylar Fracture

- Presence of IM3M generates a weak area in the mandibular angle and predisposes the angle region to fracture after injury; on the other hand, IM3M can decrease the occurrence of condylar fracture which is supposed to be the weakest area of mandible [11].
- Angle fracture is seen most commonly in patients having superficially impacted (vs deeply impacted) third molars (M3s) [12]. The reason behind this is that the mandibular strength is derived from maintenance of cortical and not the medullary bone integrity; this cortical integrity of the external ridge is disrupted by the presence of superficial impacted M3s which produce the point of weakness in the mandible and make it more prone to fractures [13].



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Fig. 52.28 (a–c) Reduction of the fracture (with the help of bone holding forceps)



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Fig. 52.29 (a, b) Use of chin retractor in reduction of fracture fragments

52.10.7.2 Open vs. Closed Reduction

Closed reduction is advisable for patients who are medically unfit for surgery (due to any reasons) or those who did not give consent for open reduction internal fixation (ORIF).

52.10.7.3 Approaches for ORIF

1. Intraoral (Fig. 52.36)
2. Extraoral (Fig. 52.26a)
3. Transbuccal (Fig. 52.37)

Intraoral incision is advocated for ORIF with single mini-plate, but higher infection rate of 13% was reported in comparison with 2% when extraoral incision was used for plating. Marginal mandibular nerve showed weakness in 8% of cases,

and it sometimes has prominent extraoral scarring in patients treated with extraoral approach [14].

Sugar [15] concluded that the combined use of transbuccal and intraoral approach is safe and effective than the intra-oral approach alone for ORIF. Author too prefers the same approach.

52.10.7.4 Advantages of Transbuccal Approach [16]

1. Less operative time
2. Minimal scar formation
3. At the time of plating, direct visualization of the occlusion
4. Low risk of injury to facial nerve



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Fig. 52.30 Application of pressure bandage



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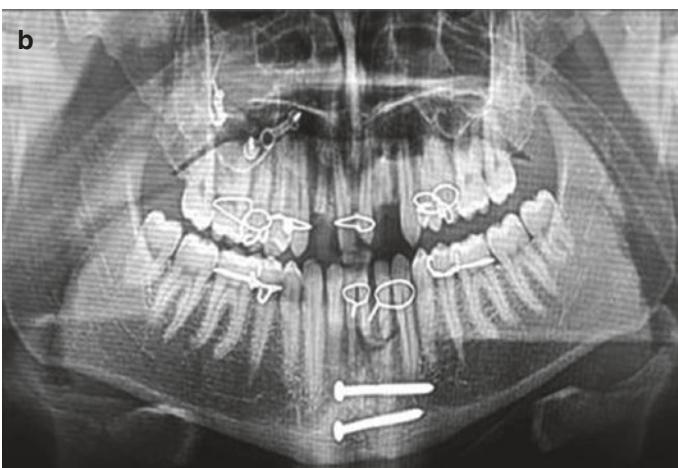


Fig. 52.32 (a, b) Fixation left para median fracture mandible with lag screws

Position of Trocar Placement [17] (Fig. 52.37)

Gulses et al. described a safe zone to place the trocar in the form of a triangle created by drawing three lines on the face.

Line 1: At the lower border of mandible (mandibular line)

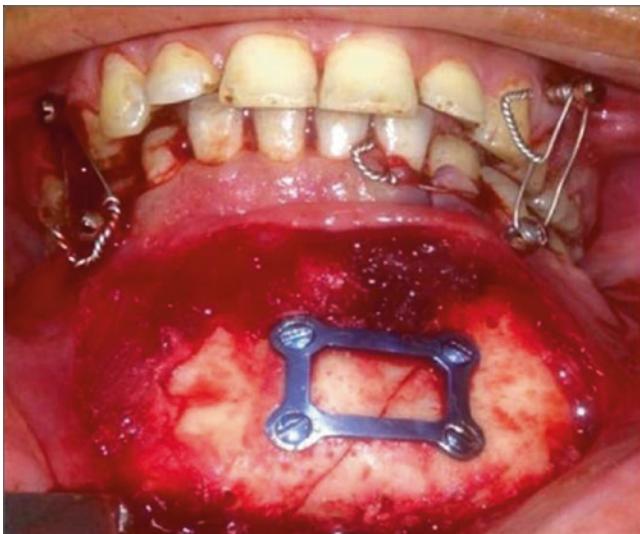
Line 2: Gonial-canthal line which ran from the gonion to the outer canthus of the eye

Line 3: Trago-basal line which ran from tragus to the groove over the body of the mandible at infero-anterior angle of the masseter (at the point of entry of the facial artery over the body of the mandible)

Table 52.8 Various fixation techniques for anterior mandibular fracture

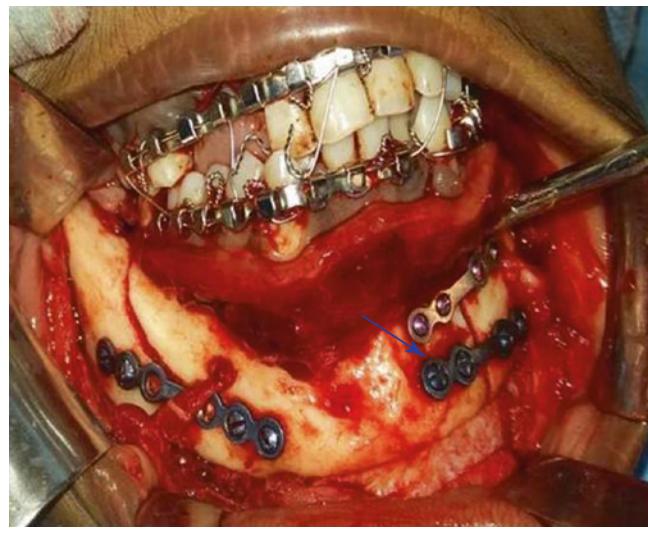
1. Reconstruction bone plates
2. Single strong nonreconstruction bone plate
3. Double miniplates
4. Two lag screws
5. Three-dimensional (3D) plate
6. Segmental arch bar with single large and stronger bone plate

Through a small stab incision, a blunt dissection is performed with dissecting scissors till the mandibular periosteum is torn and the trocar is placed through the dissected channel.



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Fig. 52.33 Fixation of anterior mandible with three-dimensional plate



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Fig. 52.35 One miniplate above and another below the mental nerve used for fixation of parasympysis fracture



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Fig. 52.34 (a–c) Existing laceration has been used as access for fixation of the anterior mandible fracture

Various techniques are mentioned in the literature for internal fixation of angle fracture (Box 52.3) [18]:

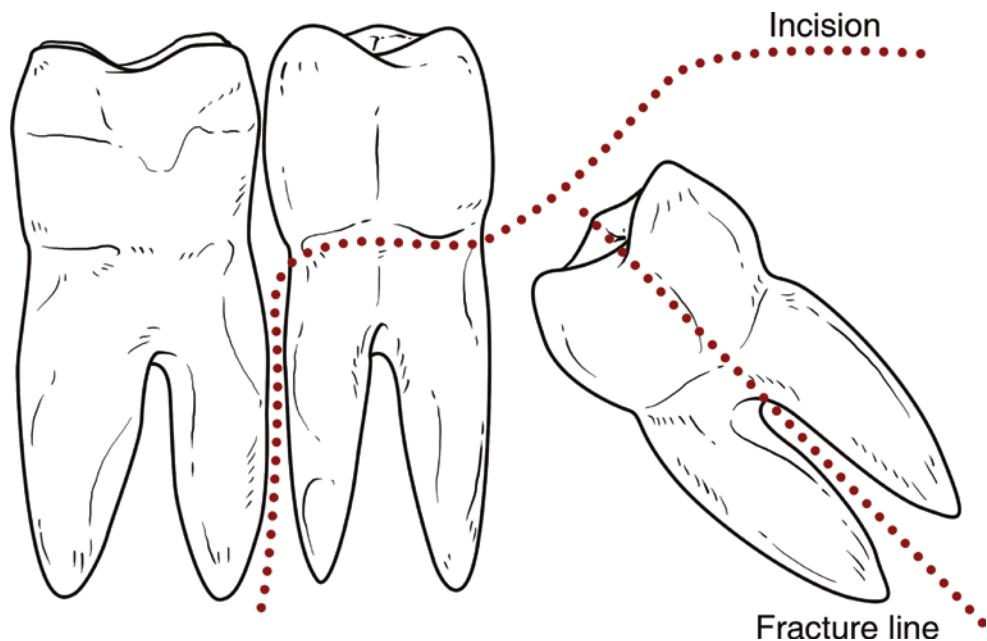
52.10.7.5 Single vs. Two Plates vs. 3D Plates

Al Moraissi [19] in a meta-analysis showed that the incidence of wound infection, dehiscence, hardware failure, and overall complications were less in patients treated with one miniplate on external oblique ridge in comparison to two.

Ellis III [20] also advocated use of single miniplate on superior border because:

Box 52.3: Fixation Techniques for Angle Fracture

1. Wire osteosynthesis (obsolete)
2. Single miniplate on the superior border (Fig. 52.38)
3. Single plate on inferior border
4. Two plates, one at superior and another on inferior border (Fig. 52.39a, b)
5. Lag screws
6. Three-dimensional plates (Fig. 52.40)



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Fig. 52.36 Intraoperative incision for exposure



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Fig. 52.37 Transbuccal approach used for fixation of angle fractures

- High rate of sequestrectomy, infection, and subsequent second surgery was more in two-plate technique.
- Fixation with two plates took more time, i.e., average 37 min in comparison to an average of 23.5 min in single miniplate fixation from incision to suturing.
- Second plate fixation at inferior border is more difficult and requires more experience.

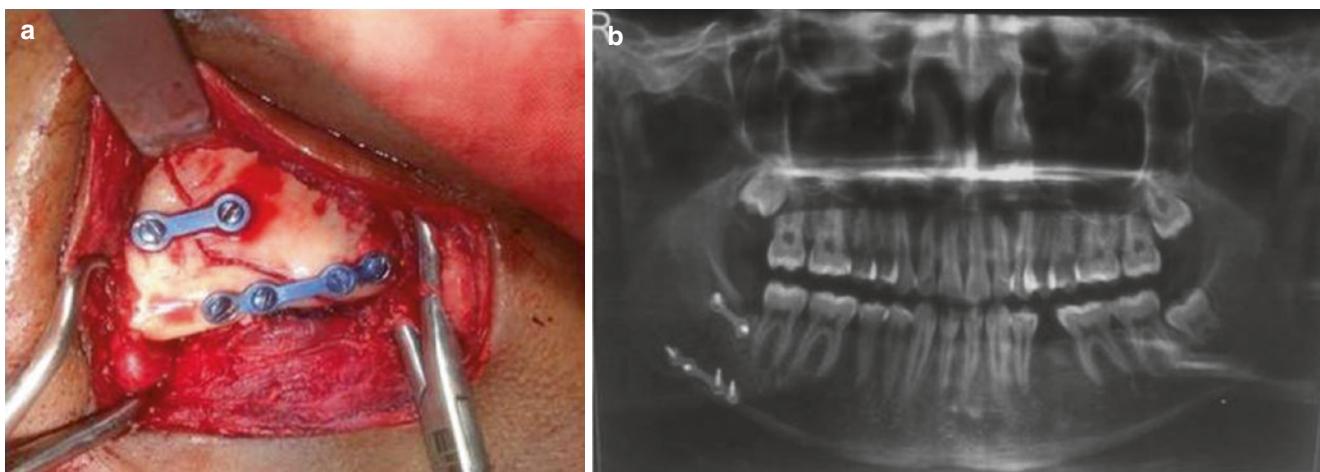


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Fig. 52.38 Fixation of mandibular angle fracture using single miniplate

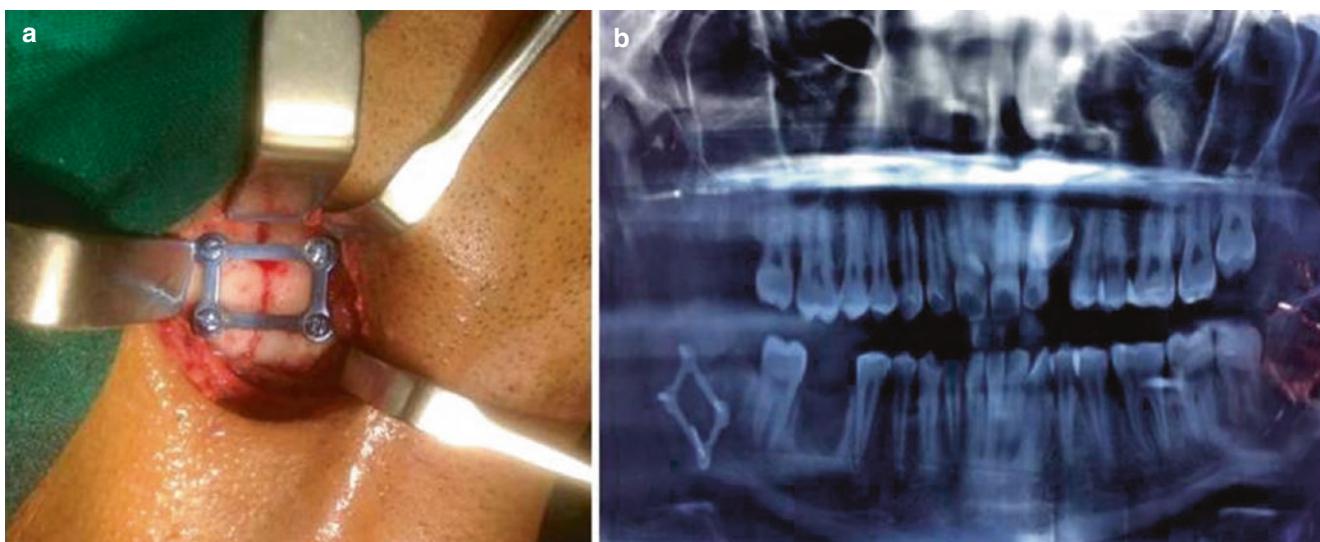
- If infection occurs, retrieval of single miniplate can be done under local anesthesia in a clinic, but two plates commonly required general anesthesia which indirectly increases the cost and prolonged the hospital stay.

Rai et al. [21] also conclude better results with two-plate fixation. Second miniplate is supposed to increase stability and protects the fracture site against torsion and bending.



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Fig. 52.39 Fixation of mandibular angle fracture using two miniplates. (a) Clinical picture, (b) orthopantamogram



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Fig. 52.40 Fixation of mandibular angle fracture using 3D plate. (a) Clinical picture, (b) orthopantamogram

Theoretically second plate establishes a second line of osteosynthesis.

Levy et al. [22] advocated two-plate fixation superior for ORIF of angle fracture. According to them two miniplates provide better stabilization and have reported lowest complication rate in comparison to any other plating technique.

Wusiman et al. [23] demonstrate that three-dimensional (3D) miniplates provide better fixation than standard mini-plates. It also provides simultaneous stabilization of tension and compression zones with lower incidence of postoperative complications and good results. According to Zix et al. [24] 1-mm-thick 3D plate is as stable as 2 mm miniplates,

and it offers better bending stability and more resistant to out of plane movement or torque.

Ellis III and Ghali [25] used lag screws for treating mandibular angle fractures but reported very high incidence of post-operative infection and bone exposure. Also the fixation of angle with lag screws is technique sensitive and requires expertise.

Kang and Zide used seven-hole angle plate when Champy technique is ineffective and more rigid or semirigid fixation is required [26]. According to them seven-hole angle plate is fixed through transfacial trocar and stabilized intra-orally. On the other hand, Champy plate required bending, lacks rigidity, difficulty in screw hole drilling, inaccurate centric placement of screws.

52.10.7.6 Extraction vs. Retention of IM3M in Angle Fracture

The use of postoperative MMF and extraction versus retention of teeth in the line of fracture did not influence any of the outcomes [27]. Increase rate of infection by extraction of a tooth was found in the study by Ellis and Walker in 1994 [28]. However, in another study published in 2002, Ellis [29] reported an increased incidence of infection if teeth were left in the line of fracture. Author advocates extraction of 3Ms at the time of ORIF for better results.

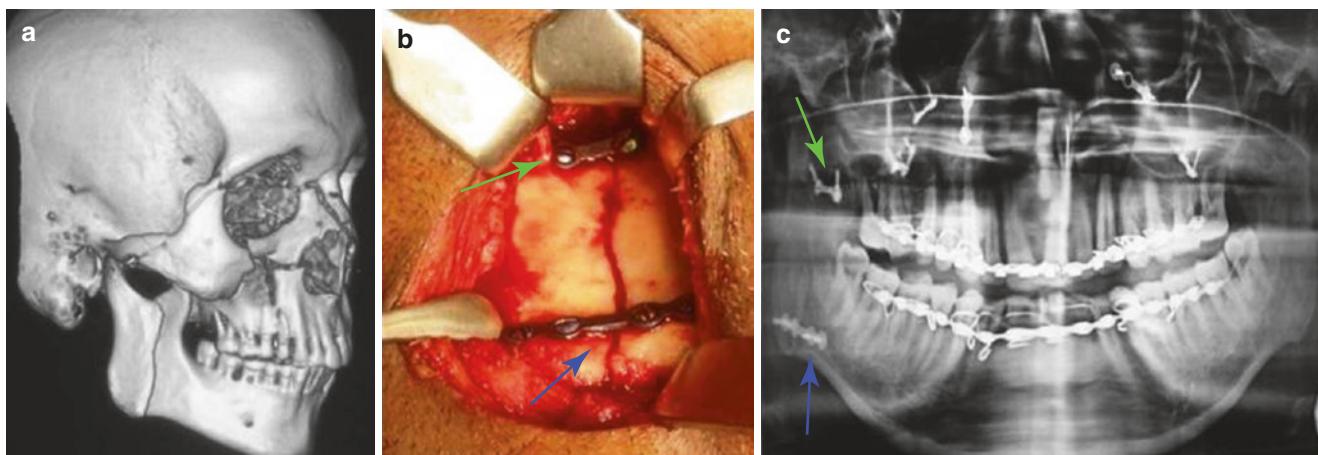
52.10.8 Body Fracture

A single four hole with gap miniplate (Fig. 52.41) below the root apex and the inferior alveolar canal is sufficient for fixation of body fracture of mandible through the intraoral approach most of the times, except when a patient is having



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Fig. 52.41 Fixation of body fracture with single miniplate



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Fig. 52.42 Management of mandibular ramus fracture. (a) DVT showing mandibular ramus fracture, (b) fixation using two miniplates, (c) postoperative orthopantomogram showing fixation of mandibular

extraoral soft tissue injury/scar or having severely comminuted fracture fragments.

52.10.9 Ramus Fracture

Mandibular ramus (MR) fracture occurs rarely and ranked third least common fracture after alveolar and coronoid fracture [30]. MR fractures are very rare in isolation. It can be horizontal or vertical. Its incidence ranges from 0.9 to 5.5% [31]. Isolated ramus fracture can be managed by closed reduction, but ORIF is the treatment of choice when it is associated with other maxillofacial fractures. To correct the facial height when midface is also fractured, the vertical rami become the only determinant, and re-establishment of these buttresses is very important before repositioning the crushed midfacial bones [32] (Fig. 52.42a–c).

52.10.9.1 Management of Triangular Fragments (TF) at the Lower Border

Heslop et al. [33] advocated repositioning of TF if they are attached to the muscle or periosteum and remove them if they are very small or detached from the periosteum.

According to Blinder et al. [34] to prevent infection and preserve vascularization, TF should be unexposed and unreduced. TF should be sandwiched between the two fracture lines by rigid fixation without exposure, and preserving vascularization may be the treatment of choice

TF of bone at the angle region were more often shown to get infected in comparison to body, symphysis, or parasymphysis because thick, better vascularized, and more cancellous bone presents in these areas as compared to angle region. It's better to remove small fragments in the angle region to avoid postoperative discomfort.

ramus and midface fractures (blue arrows point to lower border plates and green arrows point to upper border plates)

52.10.10 Coronoid Fracture

It generally occurs in combination with other fracture of the mandible (Fig. 52.43a), and with zygomatic complex fracture (commonly with arch) (Fig. 52.43b), rarely does it occur in isolation. It can be treated by extraoral or intraoral approaches. Later, having low incidence of facial nerve injury and no facial scar. Coronoid fracture ranges from 0.6 to 4.7% of all facial fractures and 1–2.9% of all mandibular fractures [35].

It manifests as [36, 37]:

- Swelling below the zygomatic arch
- Ecchymosis in the retromolar trigone area
- Restricted mouth opening, malocclusion, and facial collapse when occurs in association with other facial fractures

52.10.10.1 Indications for Conservative or Open Reduction of Coronoid Fractures

(Table 52.9)

Conservative management in the form of soft diet and mouth opening exercises to avoid bony adhesions to the surrounding structures [38]. If patients are treated with MMF and trismus occurs, it can be managed by removal of the coronoid process [39].

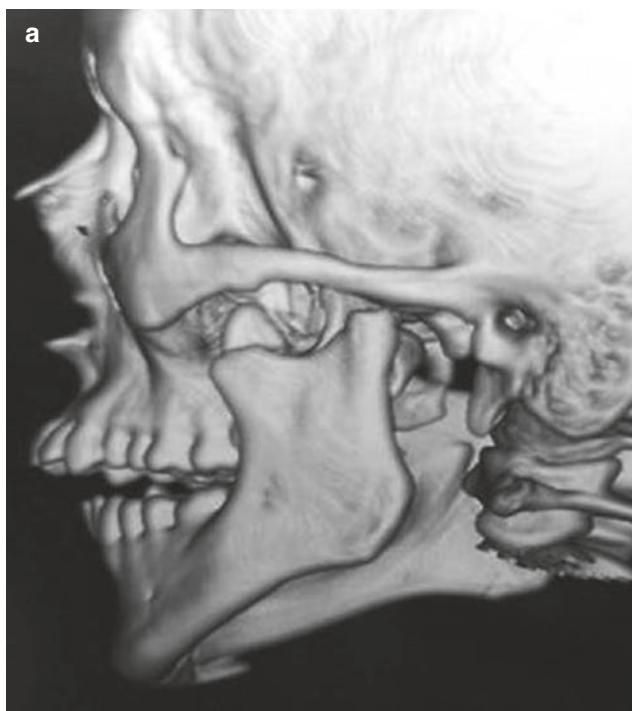
52.10.11 Bilateral Fracture of Mandible

Over half of the mandibular fractures are bilateral; in the case of angle fracture, most of the times, it occurs in combination of contralateral mandibular body and symphysis [40]. ORIF is the treatment of choice most of the times.

Clinical Tip: An MMF screw can be effectively used for reduction of a bilateral mandibular fracture by placing the screw in the symphysis region. A wire is passed through the screw, and the fracture segment can be manipulated for reduction (Fig. 52.44).

Table 52.9 Indications of closed and open reduction for coronoid fractures

Conservative	ORIF
Minimal displacement	Significant fracture displacement and Limited mouth opening
	Associated with zygoma, zygomatic arch, mandibular ramus
	Patients who are bad candidates for MMF

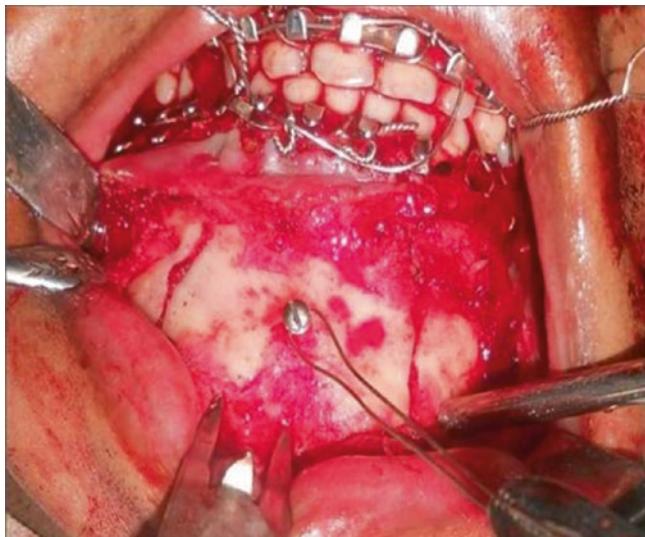


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Fig. 52.43 Coronoid fracture (a) associated with condylar fracture, (b) associated with zygomatic arch

52.10.12 Comminuted Mandible Fractures

Comminution is defined as presence of multiple fracture lines in many small pieces within the same area of mandibular angle, body, ramus, and symphysis [41]. This type of fracture rarely occurs in the condyle region. In a comminuted fracture, bone is “crushed, broken, splintered” into number of pieces, creating multiple small fragments (at least two free segments of bone) (Fig. 52.45a, b).



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Fig. 52.44 Use of MMF screw in reduction of bilateral parasympysis fracture

To fix small fragments, multiple options are mentioned in the literature like miniplate, microplate, screws, steel wires, and absorbable sutures. A fragment larger than 1 cm should be conserved, reduced, and fixed [42].

Ellis et al. [43] advocated that more complications are associated with multiple fragment fractures in comparison to fractures having few segments. Therefore, comminuted fractures need load-bearing fixation.

The bone fragments will not provide buttressing to help stabilize the fracture; therefore surgeons operating comminuted mandibular fractures having two or more free bone fragments and/or requiring bone fragment removal should opt for reconstruction plates. Miniplates can be used when comminuted mandibular fractures have only one free bone fragment. Combination of reconstruction and miniplates can be used when multiple small fragments are there in comminuted mandible fracture (Fig. 52.46). Implants used for fixation of comminuted fractures are mentioned in Box 52.4.

Use of reconstruction plates required expertise and it is time-consuming. Sometimes contour is also not favorable

Box 52.4: Implants Used for Fixation of Comminuted Fractures

1. Multiple miniplates
2. Reconstruction plates
3. Combination of mini- and reconstruction plates
4. Titanium Mesh



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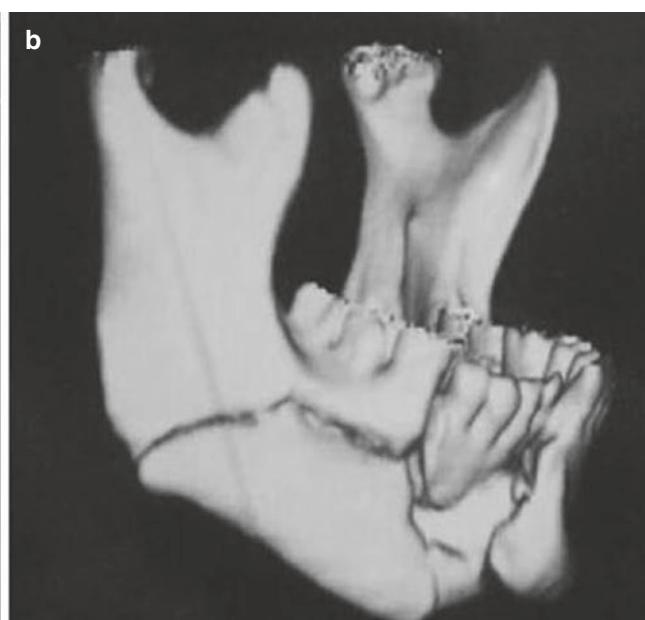
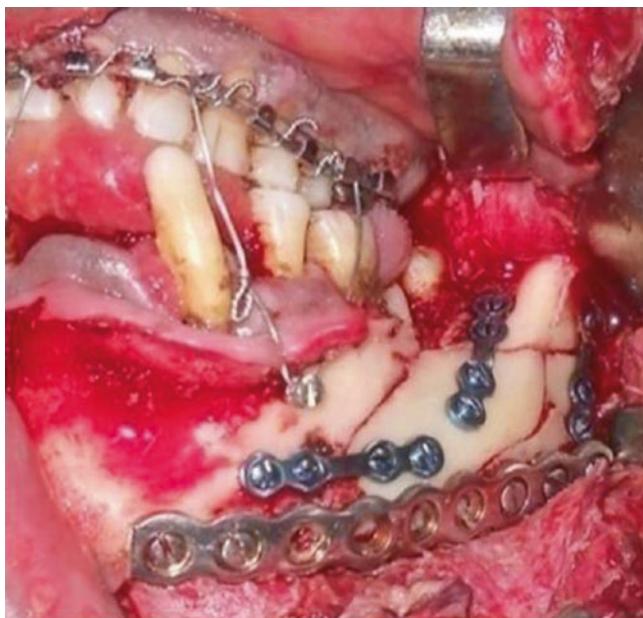


Fig. 52.45 (a, b) Comminuted fractures



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Fig. 52.46 Combination of reconstruction and miniplates in management of comminuted fractures



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Fig. 52.47 Postoperative elastics for correction of minor occlusal discrepancies (Inter maxillary elastics- IME)

which can create slight malocclusion but can be managed by postoperative elastics and selective occlusal adjustments (Fig. 52.47).

Dia et al. [44] used titanium mesh for the treatment of comminuted mandible fracture with successful results. According to them mesh required little soft tissue exposure, had low infection rate, and provides favorable mandibular morphology.

52.11 Inferior Alveolar Nerve (IAN) Injury in Mandible Fracture

According to the literature, the incidence of IAN injury was [45]:

1. 5.4–81.4% before treatment
2. 0.4–91.3% after intervention
3. 0–46.6% after 1 year

The neurosensory testing was done both before and after the treatment of mandibular fracture in which nerve injury is suspected. Two-point discrimination and pinprick testing can be used to assess the level of IAN injury. Preoperative knowledge of the patient's IAN position (based on CT/CBCT) is very important in decision-making regarding fixation position of the fracture fragments with miniplates. Plating should be done above or below the course of IAN. ORIF in the area of IAN takes longer duration to normalization of sensation, and it ranges from 1 week to 12 months. Postoperative CT/CBCT is mandatory if operating surgeon suspected the impingement of screw on the IAN or no relief of sensation after 6 weeks of ORIF for further management. Surgeons should not hesitate to redo the surgery in cases of IAN injury by miniplates and screws.

52.12 Geriatric Mandibular Fracture

With old age, the incidence rate of maxillofacial fracture increases, with mandibular fracture appearing with a greater frequency. As the age advances, the weakening of the mandible occurs due to:

- Loss of teeth
- Reduced vascularity or decreased blood flow in elderly
- Loss of bone mass

The most common mechanisms of injury in geriatric patients are [46]:

1. Fall
2. Assaults
3. Motor vehicle accidents

Fractures of the edentulous mandible pose unique challenges. Old age itself is a risk factor for poor outcomes following trauma. There are associated comorbidities like hypertension, diabetes mellitus, dementia, or stroke which limit the functional capacity of the patient to bear the stress of surgery and postoperative recovery. Also, the atrophic mandible has compromised blood supply with little osteo-

genic potential resulting in delayed bone healing. Bilateral mandibular fracture (bucket handle fracture) occurs most commonly in elderly (Fig. 52.48).

52.12.1 Management

Controversy exists in the treatment of edentulous mandibular fracture. One school of thought advocated closed reduction, and another school is in favor of open reduction and internal fixation. According to Bradley [47] the major blood supply to the mandible is “sub periosteal Plexus,” and reflection of periosteum in ORIF may seriously impair vascular supply to the bone resulting in non-union.



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Fig. 52.48 Bilateral mandibular fracture (bucket handle fracture) in edentulous patients

Controversy again exists in the use of bone grafts in edentulous mandible. Are bone grafts necessary? Answer is not always. Reconstruction plates (load-bearing plates) can be used for comminuted fractures and with large defects. Bone morphogenic proteins and tricalcium phosphate can be used as alternative to autogenous grafts in patients whom multiple comorbidities may influence local or systemic outcomes [48].

Few authors advocated extramucosal intraoral plating for the ORIF of the edentulous mandibular fracture. It preserves the blood supply to the mucosa and bone, at the same time provides adequate stability [49, 50].

The techniques of edentulous atrophic mandible fracture management are:

1. Closed reduction (CR)

This technique is opted when the patient's systemic condition does not allow for an open surgery. CR can be accomplished if the mandibular height is at least 30 mm. It is difficult to achieve CR if the mandibular height is <10 mm. CR can be accomplished using a preexisting denture. If there is no denture, gunning splint can be prepared. The denture/splint is used for immobilization and fixed to the mandible with circum-mandibular wiring (Fig. 52.49a, b).

Advantages: Periosteal supply to the bone is maintained.

Disadvantages: Chances of infection and pulmonary issues

2. Open reduction and internal fixation (ORIF)

This involves use of plates and screws for fixation of fractures. Options for ORIF include use of miniplates or larger reconstruction plates. Miniplates are small and



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Fig. 52.49 (a) Securing gunning splint by circum-mandibular wiring, (b) MMF with gunning splint in situ

hence require smaller incision. Screws of miniplates are also small which can easily involve thin fragments. However, in cases of larger fractures, a load-bearing reconstruction plate is preferred.

Advantages: Adequate fixation with no/minimum MMF

Disadvantages: Delayed healing with periosteal blood supply loss

52.13 Pediatric Mandibular Fractures

Among all the maxillofacial fractures, the incidence of pediatric facial fracture is 1–15%. After nasal bone fracture, the second most common fractures in children are mandibular fracture with an incidence of 5–50% [51]. In mandible, the condyle is the commonest site of fracture in pediatric patients followed by symphysis and parasymphysis. The most common mechanisms of injury in children are [52]:

1. Fall from height
2. Bicycle falls
3. Automobile and sports accidents
4. Violence

In children, the developing tooth buds of canine approximate the lower border of mandible. This creates a stress point making the mandible susceptible to fracture in this location. Once the canine erupts, this weak point is reinforced with the bone and is not weaker than any other regions of the mandible. This is the reason probably why parasymphysis fracture is more common in children than adolescents.

With increasing age, the skull-to-face ratio decreases. The larger cranium shields the smaller middle and lower thirds of the face from injuries. This prevents mandibular fracture in small children; however, with increasing age the mandible becomes more prominent resulting in more injuries to this region.

52.13.1 Management

The management of pediatric mandibular fractures is different in comparison to adults due to [53]:

1. Relatively small size of maxillofacial bones
2. Presence of tooth germs
3. Soft bone with good elasticity
4. Instability of deciduous or mixed dentition
5. Rapid repair process
6. Difficulties in cooperation and acceptance

Pediatric mandibular fractures are treated in the following ways:

1. Undisplaced fractures: Managed conservatively with close observation, soft diet, analgesics, and activity prevention
2. Fractures with minor malocclusions: A short period of MMF with the help of bondable buttons and wires for 7–14 days
3. Malocclusion with displacement of segments: Closed reduction using cap splint secured to mandible by circum-mandibular wiring (Fig. 52.50a–c)
4. Malocclusion with severe displacement requiring three-dimensional stabilizations: open reduction and internal fixation

However the absence of teeth due to exfoliation and poor retention of wires on the deciduous teeth crowns makes the ligature wire and traditional use of arch bars difficult or sometimes impossible [54]. In such cases splinting with acrylic splint retained with circum-mandibular wires remains a viable option in treatment of pediatric mandibular fractures.

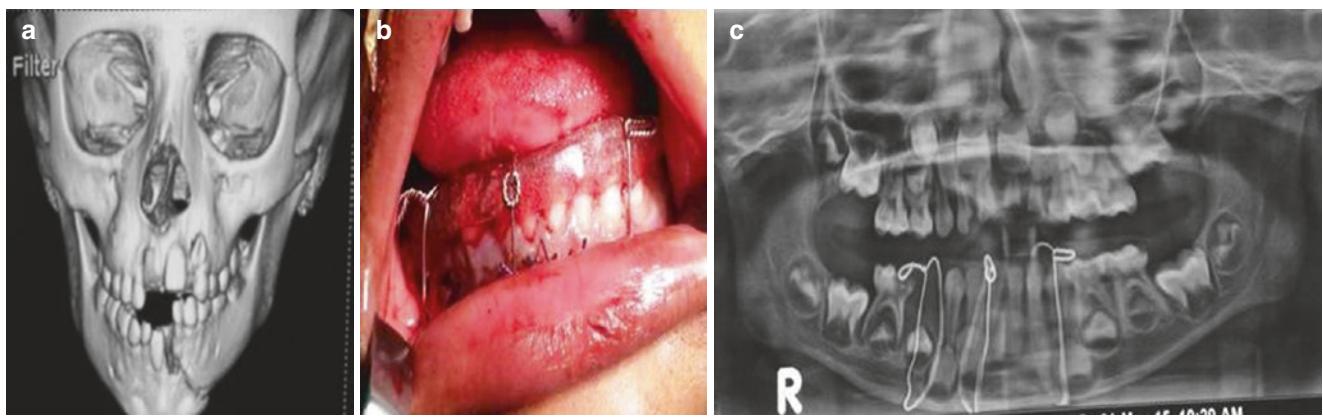
Cap splints are secured to mandible by circum-mandibular wiring. Kelsey Fry bone awl is used for this purpose. A wide-bore needle can also be used for the same (Fig. 52.51a, b). Intravenous cannula stilette (IVCS) is also mentioned in the literature for performing circum-mandibular wiring. The 16-gauge IVCS was used instead of conventional awl [55].

However, management of pediatric mandibular fracture with ORIF is controversial as the fixation of plates may hamper the growth and development of jaw. Titanium miniplates have been successfully used for ORIF, but the implants are to be removed within 3- to 12-month period [56].

Yerit et al. [57] proposed use of biodegradable plates for ORIF. These plates should be mechanically strong and must undergo resorption within a predictable time frame.

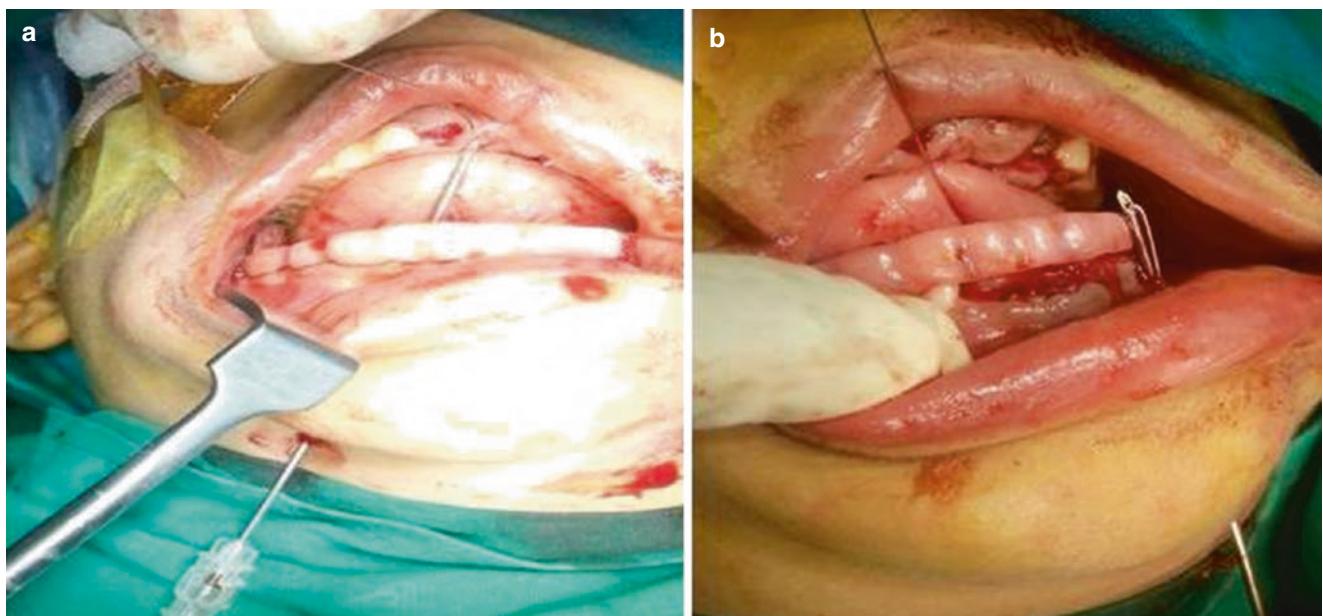
The advantages of biodegradable plates (polyglycolic and poly-L-lactic acid plating system) in comparison to titanium plates are [58]:

1. Does not require second operation for removal, indirectly becoming cost-effective and requiring less hospital visit.
2. Does not cause growth disturbances.
3. Monocortical plates and screws do not cause damage to the tooth buds.



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Fig. 52.50 (a) Pediatric mandibular fracture, (b) cap splint secured using circum-mandibular wiring, (c) postoperative orthopantomogram



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Fig. 52.51 (a, b) Securing cap splint by circum-mandibular wiring using wide-bore needle

52.14 Use of Bone Grafts in Mandible Fracture Treatment

Anterior iliac crest (cancellous or cortico-cancellous) and fibula (free microvascular reconstruction) are the most commonly used sites from where the bone grafts are used for mandibular reconstruction. All the cases required bone grafting in cases of mandibular fracture treated with ORIF should be kept in MMF of 4 weeks postoperatively.

Bone grafts are indicated in some cases of:

1. Severely comminuted fractures
2. Gunshot wounds
3. In non-union
4. Atrophic mandibular fractures

Rachmiel et al. [59] advocated two-stage reconstruction of mandibular bone defect after trauma by bone grafting followed by alveolar distraction osteogenesis (ADO). This modality helps in correction of intermaxillary vertical relationship and provides sufficient amount of bone for the placement of dental implants and prosthesis.

52.15 Postoperative Care

- Pressure dressing over the site to avoid postoperative hematoma in required cases.
- Elastic traction for correction of minor discrepancies in occlusion (Fig. 52.47).
- Soft and liquid diet.
- Maintenance of oral hygiene by oral rinses.
- Recall visit for review.
- Follow-up appointments and if results are not satisfactory frequent follow-up required.
- If patient is not satisfied, plan for retreatment.

52.16 Complications of Mandible Fracture

Immediate

- Pain
- Swelling

Delayed

- **Infection:** Found to be the most common complication (Fig. 52.52)



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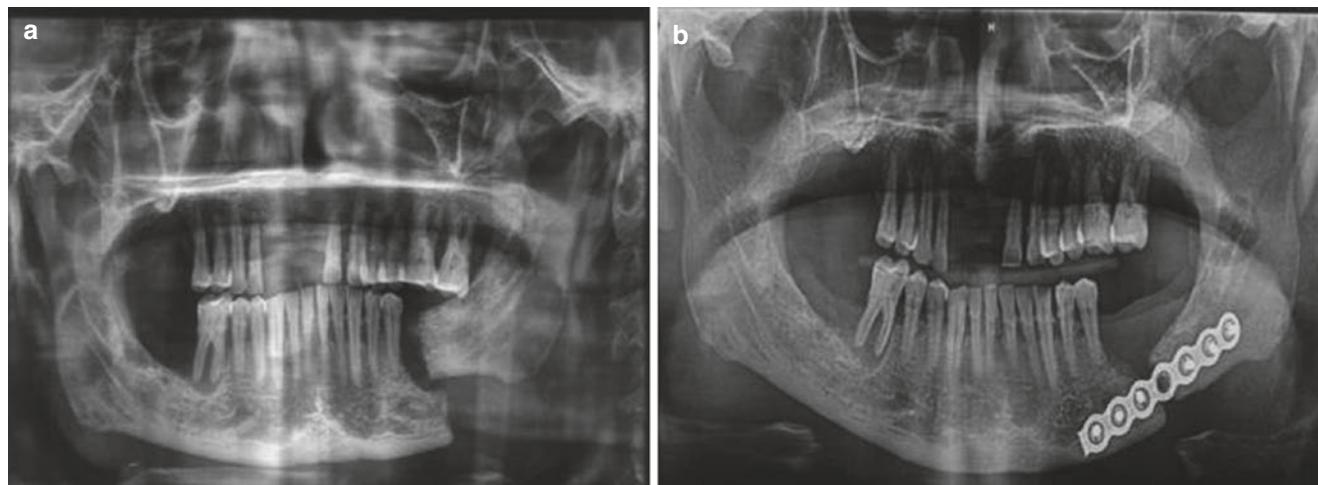
Fig. 52.52 Postoperative infection

- Predisposing factors:
 1. Preoperative oral sepsis
 2. Tooth in the line of fracture
 3. Improper reduction and fixation (Fig. 52.53)
 4. Alcoholic or metabolic disturbances
 5. Prolonged time before treatment
 6. Poor patient compliance
- **Malunion**
 - It indicates that a fracture has healed but in less than an optimal position.
 - It may result when bone is shorter than normal, rotated or twisted in a bad position, or bent.
 - It may cause pain, joint degeneration, posttraumatic arthritis, or catching episodes resulting from instability.
- **Non-union**
 - It is a type of uncommon complication of mandibular fracture, with reported incidence of 2.8–3.9% [60].
 - It is failure of fracture hematoma to become transformed into an osteogenic matrix so that it is converted into non-osteogenic fibrous tissue.
 - Non-union identified by mobility in all planes after interval of minimum 10 weeks.
 - Histologically there is absence of identifiable osteogenic tissue.
 - Radiographically no evidence of progressive decrease in radiolucency at the fracture site and rounding off of the bones' end in the later stages. It can be treated by ORIF by rigid fixation (load-bearing reconstruction plate and sometimes in combination with bone graft) (Fig. 52.54a, b).



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Fig. 52.53 Postoperative infection due to improper reduction and fixation



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Fig. 52.54 (a) Non-union due to closed reduction, (b) management of fracture non-union by load-bearing reconstruction plate

Table 52.10 Management of mandibular non-union

If the defect is <1 cm	Defect size: 1–6 cm		Defect > 6 cm
Rigid internal fixation in single stage	If adequate soft tissue present	If adequate soft tissue absent	Reconstruction with vascularized bone flap in single stage
	Reconstruction with bone graft in single stage	Reconstruction with bone graft at a later stage	
		Reconstruction with vascularized Bone flap in single stage	



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Fig. 52.55 Showing malocclusion

52.16.1 Management of Mandibular Non-union Depending upon the Size of the Defect (Table 52.10) [61]

- Malocclusion (Fig. 52.55)
- Facial asymmetry (Fig. 52.56)



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Fig. 52.56 Facial asymmetry

- Mandibular growth disturbances
- Disruption of permanent teeth
- TMJ dysfunction

52.17 Recent Advances

Kokosis et al. [62] advocated use of virtual surgical planning (VSP) with subsequent computer-aided design and manufacturing in management of acute mandibular trauma patients.

The advantages of the use of custom titanium plate in mandibular trauma are:

1. Avoid need for in situ bending.
2. Serving as a guide and confirming accurate reduction.
3. Customized titanium plates are much stronger than conventional plates.
4. Less palpable.

Computer-assisted surgery (CAS) including computer-aided design and manufacturing, surgical navigation techniques, and rapid prototyping (RP) has been used with lot of success in mandibular reconstruction (refer Chap. 41 of this book).

CAS helps in [63]:

1. Preoperative planning
2. Preparation of stereolithographic (STL) models or accurate implantation material
3. Implementation of complex design through intraoperative navigation

Some Important Facts from Review of Literature Regarding Mandible Fracture [64, 65]

1. Injuries caused by assaults were more prone to develop postoperative infection, nerve damage, and malocclusion.
2. 11.8-fold more likely to have poor radiographic outcome in patients with comminuted fracture.
3. Dehiscence, nerve injury, and malocclusion occur more commonly in surgeries taking longer duration.
4. Patients with three or more fractures were 13.8-fold more likely to develop postoperative trismus in comparison to single fracture.
5. Chances of complications are more in patients who took discharge against medical advice.
6. Treatment of isolated mandible fracture can be safely delayed to allow for more improved resource distribution and prioritization of more time-dependent interventions.

52.18 Case Scenarios

Case Scenario 1

A male patient reported with a gunshot injury over right side of face. Patient's Glasgow coma scale (GCS) was 15/15 with stable vital signs, but the patient has difficulty in breathing. On maxillofacial examination, a gunshot wound was present over right side of face at the right mandibular angle region. Deviation of mandible was present on right side with cross bite on right side and open bite on left side. Tenderness was present over right mandibular angle region. On palpation, intersegmental mobility was present over right angle region.

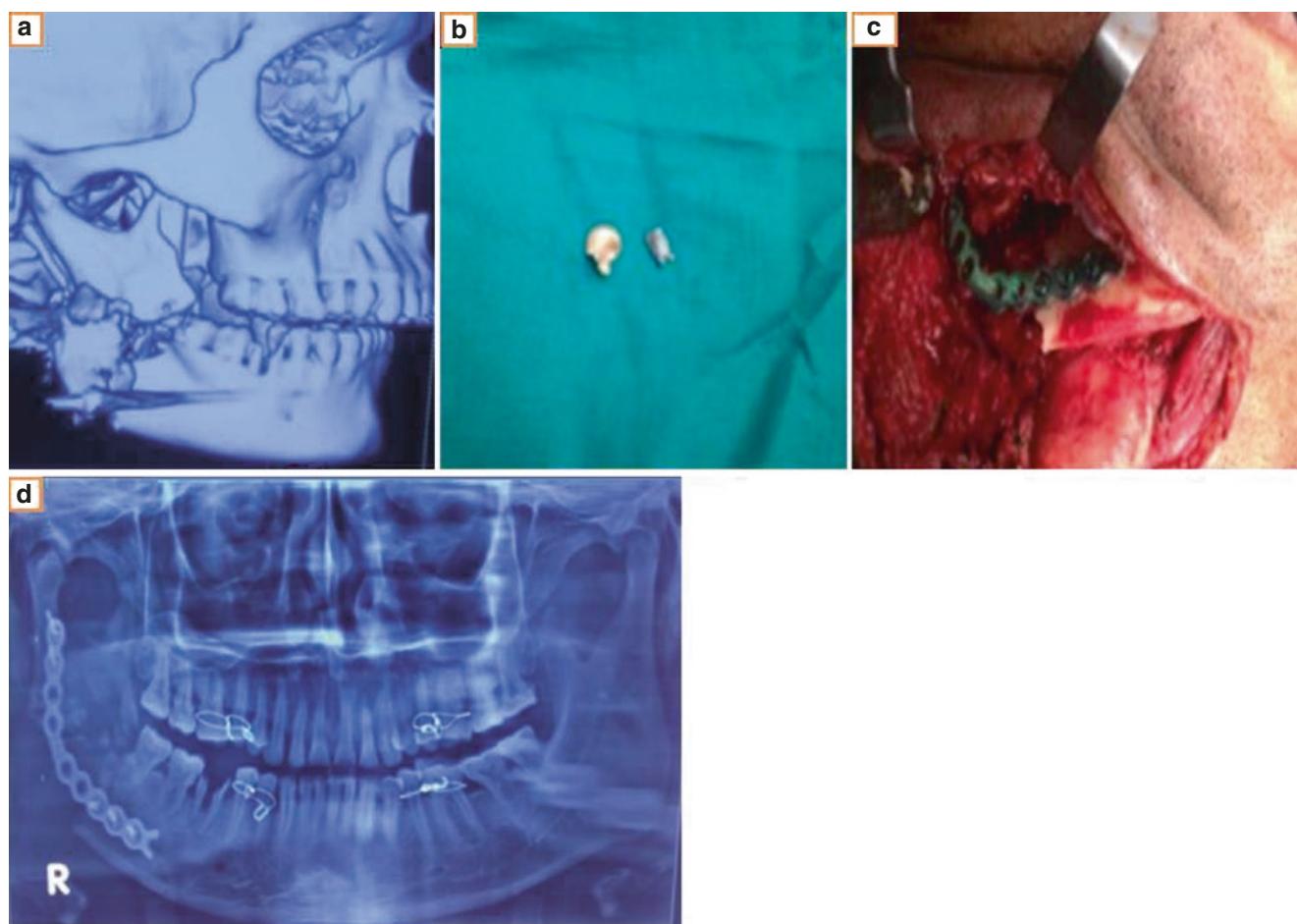
Provisional diagnosis: Right mandibular angle fracture following gunshot

Investigation: Apart from blood investigation, a CT scan was performed, and a final diagnosis of comminuted right mandibular ramus and angle fracture with bullet in situ was made (Fig. 52.57a).

Management: Patient was subjected to emergency surgery under general anesthesia with a treatment plan of bullet retrieval, debridement, and open reduction and internal fixation of fracture. After the anesthesia was induced, patient preparation was done; the fracture site was exposed through an extraoral approach. Thorough debridement was done, and bullet was retrieved in multiple pieces (Fig. 52.57b). The bone segments which were detached were removed, and the fracture segments were fixed using a reconstruction plate following achieving occlusion (Fig. 52.57c). The use of bone graft was eliminated considering the risk of postoperative infection due to scattering of bullet particles. Moreover, the fracture site was a non-dentate site; hence bone grafting was not mandatorily indicated for postoperative dental rehabilitation. Figure 52.57d shows postoperative OPG and fixation of fracture with reconstruction plate (refer Chap. 59 on Gun shot injuries).

Case Scenario 2

A female patient reported with the chief complaint of difficulty in chewing following operation to treat mandibular fracture. Patient gave a history of fall from height following which she was operated for ORIF elsewhere. The general condition of patient was good. On maxillofacial examination, mandible was deviated on right side with cross bite on right



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Fig. 52.57 Case Scenario 1 (a) DVT showing comminuted right mandibular angle and ramus fracture with bullet in situ; (b) retrieved bullet; (c) bullet retrieval, debridement, and fixation of fracture with recon-

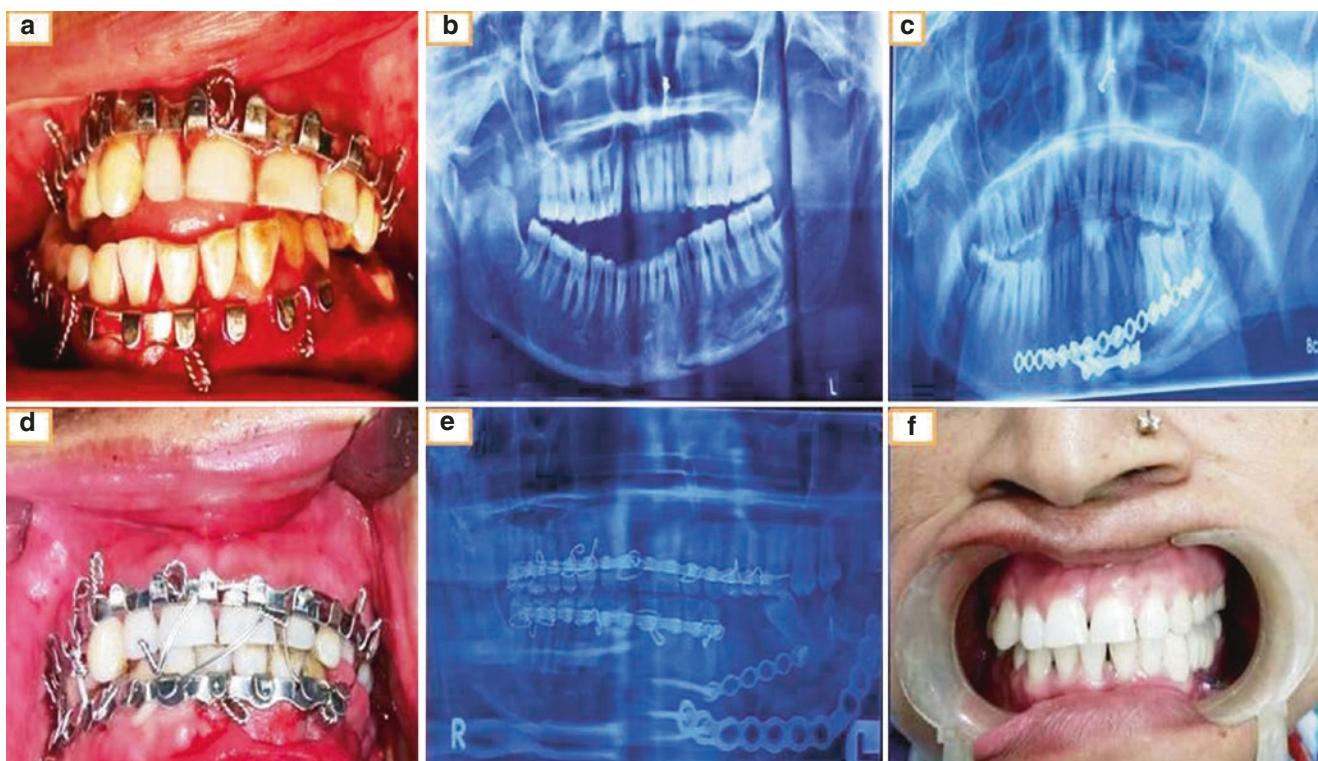
struction plate; (d) postoperative OPG showing fixation of fracture with reconstruction plate

side and open bite with lingualized occlusion on left side (Fig. 52.58a). Patient provided us with a pretreatment OPG which revealed right subcondylar with left side mandibular comminuted body and angle fracture (Fig. 52.58b). We subjected the patient to another OPG which revealed improper fixation of left mandibular body fracture and no fixation of left angle and right subcondylar fracture (Fig. 52.58c).

Diagnosis: Malunited left mandibular body, left angle fracture, and right subcondylar fracture

Management: Patient was subjected to general anesthesia. Once the anesthesia was induced, patient preparation was

done, and fracture site was exposed through extraoral incision for all the fractures. Existing implants were removed which resulted in removal of few small bone fragments. The fractured and carious teeth were extracted and reduction was done by MMF. Occlusion was achieved (Fig. 52.58d), and fixation was performed using two miniplates at subcondylar site and load-bearing reconstruction plate at the body-angle unit. A postoperative OPG was done (Fig. 52.58e). Patient was discharged in stable condition. After 6 months, dental rehabilitation was performed for missing teeth by delivering dental bridge (Fig. 52.58f).



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Fig. 52.58 Case scenario 2 (a) Deranged occlusion when patient reported to us, (b) pretreatment OPG, (c) improper fixation of left mandibular body fracture and no fixation of left angle and right subcondylar

fracture at other centre, (d) intraoperative occlusion achieved, (e) post-operative OPG, (f) postoperative accurate occlusion

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