Republic of Iraq
Ministry of Higher Education
And scientific Research
University of Baghdad
College of Dentistry

Management of mandibular bone fracture

A Project Submitted to
The College of Dentistry, University of Baghdad, Department of oral surgery
in Partial Fulfillment for the Bachelor of Dental Surgery

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May, 2022

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Certification of the Supervisor

I certify that this project entitled " **Management of *mandibular bone fracture*"** *was prepared by the fifth-year student "***Hussein Khalil***" and "***Hussein Shakir***" under my supervision at the College of Dentistry/University of Baghdad in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.*

Dr. Salah Jasim
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Dedication

This project is wholeheartedly dedicated to our beloved parents, who have been our source of inspiration and gave us strength when we thought of giving up. To our brothers, sisters, relatives, mentor, friends, and classmates who shared their words of advice and encouragement to finish this study

Acknowledgment

We would like to express our gratitude to Dr.Raghad Abd alrazaq Dean of College of Dentistry, University of Baghdad and Assistant Prof. Dr. Sahar Shakir the Head of the Department of oral and maxillofacial surgery. Our deep appreciation to our supervisor Dr. Salah Jasim For his guidance, support and encouragement through this project. Then we dedicate this work to everyone who taught us and helped us all over the past 17 years in our life, to those who have special personality, thinking and laughing that made every moment in our life different and special.

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RTA	Road traffic accident
MMF	Mandibulo-Maxillary fixation
3D	Tree Dimension
3M	Third molar
MR	Mandibular ramus
IAND	Inferior alveolar nerve dysfunction
CNST	Clinical neurosensory testing
IAN	Inferior alveolar nerve
NSD	Neurosensory disturbance
OPG	Orthopantomograph
CT scan	Computerized tomography scan
PAN	Panoramic radiography
MSCT	Multislice spiral computed tomography
CBCT	Cone beam computed tomography
MRI	Magenti resonance imaging
ABC	Airway breathing imaging
IMF	Intermaxillary fixation
ORIF	Open reduction internal fixation
IAN Injury	Neurosensory testing

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Abstract

The mandibular bone is an important component of the facial bone, which has a unique role in digestive system, speech, and facial esthetics. For these important functions of mandibular bone, it is vital that surgeons should not only treat function but also consider the esthetics together. Mandibular fractures are among the most common traumatic injuries of the maxillofacial region. Even though treatment modalities are well established and being practiced for a long time, untreated and postoperative Complication still decrease.

INTRODUCTION

The mandibular bone is an important anatomical and functional structure, constitutes the lower height and width of the facial skeleton, the mandible is a complex bony structure and has a vital anatomical articulation with other cranio-maxillofacial components, it has a fundamental function in digestive system and also plays an important role in speech and facial expression **(Stacey *et al*., 2006).** Mandibular fractures are among the most common (60–70%) maxillofacial fractures observed in emergency rooms (**Naeem *et al*., 2017).** More than 2,500 people suffer a mandibular fracture every year in the USA (**Afrooz *et al*., 2015).** The epidemiology of maxillofacial fractures varies according to geographical areas and socio-economic factors. The most common causes of maxillofacial fractures are road traffic accidents, falls, assaults, sports, and work injuries (**Marker *et al*., 2000).** The average age of patients with mandibular fracture is 38 years for men and 40 years for women (**Doerr, 2015).** Men are mainly involved (male-to-female ratio 5:1) **(Jadhav *et al*., 2015).**

Mandibular fractures can be classified in relation to their anatomic localization as follows: symphysis/parasymphysis, angle, ramus, condyle, and coronoid process (**Nardi *et al*., 2020).**

Mandibular fractures are found in 44.2% of patients who are admitted to emergency rooms for facial trauma, and only in 7% of cases is a mandibular fracture not confirmed by the findings of imaging investigations when it is clinically suspected (**Yildirgan *et al*., 2016).**

Treating mandibular fractures involves providing the optimal environment for bony healing to occur: adequate blood supply, immobilization, and proper alignment of fracture segments.Most fractures require reduction and fixation to allow for primary or secondary bone healing. The one exception is the unilateral subcondylar fracture in the patient with a normal occlusion **(Koshy *et al*.,2010).**

Indirect (secondary) fracture healing is the most common form of fracture healing, and consists of both endochondral and intramembranous bone healing **(Gerstenfeld *et al*.,2006).**

It does not require anatomical reduction or rigidly stable conditions. On the contrary, it is enhanced by micro-motion and weight-bearing. However, too much motion and/or load is known to result in delayed healing or even non-union **(Green *et al*.,2005).**

Indirect bone healing typically occurs in non-operative fracture treatment and in certain operative treatments in which some motion occurs at the fracture site such as intramedullary nailing, external fixation, or internal fixation of complicated comminuted fractures **(Pape *et al*.,2002).**

Direct healing does not commonly occur in the natural process of fracture healing. This since it requires a correct anatomical reduction of the fracture ends, without any gap formation, and a stable fixation. However, this type of healing is often the primary goal to achieve after open reduction and internal fixation surgery. When these requirements are achieved, direct bone healing can occur by direct remodeling of lamellar bone, the Haversian canals and blood vessels. Depending on the species, it usually takes from a few months to a few years, before complete healing is achieved **(Rahn *et al*.,2002).**

1.1 Mandibular bone

1.1.1 Embryology

The development of the mandible originates from the branchial apparatus. The branchial apparatus divides into three main components. The components are the branchial clefts, arches, and pouches. The branchial clefts are made up of ectoderm. The only significant branchial cleft is the first one. This first branchial cleft will develop into the external acoustic meatus. The composition of the branchial arches is of neural crest cells and mesoderm. The branchial arches are responsible for developing into the muscles, bones, and nerves of the face and neck. While the branchial pouches will develop into the organs in the face and neck such as the tonsils, parathyroid, and thymus. Simultaneously, the arterial system in the head, face, and neck will develop from the aortic arches; the aortic arches will differentiate around the same time as the structures from the branchial apparatus.

The first branchial arch will form the mandible. The grooves and impressions in the mandible will develop as the other tissues differentiate. As the inferior alveolar nerve and artery develop and travel toward the oral cavity, the mandibular foramen will develop. The mandibular foramen will form to protect the inferior alveolar nerve and vessels (**Nguyen *et al*.,2021).**

1.1.2 Structures of the mandible

The mandible is made up of the following parts:

1.1.2.1 Body

The body is the anterior portion of the mandible and is bound by two surfaces and two borders. The body ends and the rami begin on either side at the angle of the mandible, also known as the gonial angle.

A. External surface**:** The external surface contains the mandibular symphysis at midline, detected as a subtle ridge in the adult. The inferior portion of the ridge divides and encloses a midline depression called the mental protuberance. The edges of the mental protuberance are elevated, forming the mental tubercle. Laterally to the ridge and below the incisive teeth is a depression known as the incisive fossa. Below the second premolar is the mental foramen, in which the mental nerve and vessels exit. The oblique line courses posteriorly from the mental tubercle to the anterior border of the ramus.
B. Internal surface***:*** The internal surface contains the median ridge at midline and mental spines, which are just lateral to the ridge. The mylohyoid line begins at midline and courses superiorly and posteriorly to the alveolar border.
C. Alveolar border*:* The alveolar border, which is the superior border, contains the hollow cavities in which the lower sixteen teeth reside.
D. Inferior border***:*** The inferior border creates the lower jawline and contains a small groove in which the facial artery passes **(Breeland *et al.*.,2021)**.

1.1.2.2 Ramus

The ramus contributes to the lateral portion of the mandible on either side. The coronoid process and condyloid process are located at the superior aspect of the ramus. The coronoid process is anterior, and the condyloid process is posterior, the two are separated by the mandibular notch. The ramus is bound by two surfaces and four borders and contains two processes **(Breeland *et al*.,2021)**.

A. Lateral surface***:*** The lateral surface contains a portion of the oblique line, which began on the external surface of the body. This surface also provides the origin for the masseter muscle.
B. Medial surface***:*** The medial surface contains the mandibular foramen through which the inferior alveolar nerve and inferior alveolar artery enter and subsequent course the mandibular canal. At the anterosuperior aspect of the mandibular foramen is a sharp process called the lingula of the mandible. At the posteroinferior aspect of the mandibular foramen is the mylohyoid groove, against which the mylohyoid vessels run.
C. Superior border***:*** The superior border which gives rise to the coronoid and condyloid processes.
D. Inferior border***:*** The inferior border is continuous with the inferior border of the mandibular body and contributes to the jawline.
E. Posterior border***:*** The posterior border is continuous with the inferior border of the ramus and is deep to the parotid gland. This border is used in conjunction with the inferior border of the mandibular body to determine the gonial angle.

F. Anterior border***:*** The anterior border is continuous with the oblique line of the external surface of the body **(Breeland *et al*.,2021)**.

1.1.2.3 Coronoid Process

The coronoid process is located at the superior aspect of the ramus. Its anterior border is continuous with that of the ramus, and its posterior border creates the anterior boundary of the mandibular notch. The temporalis muscle and masseter insert on its lateral surface **(Breeland *et al*.,2021)**.

1.1.2.4 Condylar Process

The condylar process is also located at the superior aspect of the ramus and is divided into two parts, the neck, and the condyle. The neck is the thinner portion of the condyloid process that projects from the ramus. The condyle is the most superior portion and contributes to the temporomandibular junction by articulating with the articular disk **(Breeland *et al*.,2021)**.

1.1.3 Blood Supply and Lymphatics

Blood supply to the mandible is via small periosteal and endosteal vessels. The periosteal vessels arise mainly from the inferior alveolar artery and supply the ramus of the mandible. The endosteal vessels arise from the peri-mandibular branches of the maxillary artery, facial artery, external carotid artery, and superficial temporal artery, these supply the body of the mandible (**Saka *et al*.,2002)**.

The mandibular teeth are supplied by dental branches from the inferior alveolar artery.

Lymphatic drainage of the mandible and mandibular teeth are primarily via the submandibular lymph nodes; however, the mandibular symphysis region drains into the submental lymph node, which subsequently drains into the submandibular nodes.

1.1.4 Nerves

The main nerve associated with the mandible is the inferior alveolar nerve, which is a branch of the mandibular division of the trigeminal nerve. The inferior alveolar nerve enters the mandibular foramen and courses anteriorly in the mandibular canal where it sends branches to the lower teeth and provides sensation. At the mental foramen, the inferior alveolar nerve branches into the incisive and mental nerve. The mental nerve exits the mental foramen and courses superiorly to provide sensation to the lower lip. The incisive nerve runs in the incisive canal and provides innervation to the mandibular premolar, canine, and lateral and central incisors **(Lee *et al*.,2015).**

1.1.5 Muscles

<u>1.1.5.1 Muscles Originating from the Mandible</u>

A. Mentalis - originates from the incisive fossa.
B. Orbicularis oris - originates from the incisive fossa.
C. Depressor labii inferioris - originates from the oblique line.
D. Depressor anguli oris - originates from the oblique line.
E. Buccinator - originates from the alveolar process.
F. Digastric anterior belly - originates from the digastric fossa.
G. Mylohyoid - originates from the mylohyoid line.
H. Geniohyoid - originates from the inferior portion of the mental spine.
I. Genioglossus - originates from the superior portion of the mental spine.
J. Superior pharyngeal constrictor - originates partially from the pterygomandibular raphe, which originates from the mylohyoid line.

1.1.5.2 Muscles Inserting on the Mandible

A. Platysma - inserts on the inferior border of the mandible.

B. Superficial masseter - inserts on the lateral surface of the ramus and angle of the mandible.

C. Deep masseter - inserts on the lateral surface of the ramus and angle of the mandible.

D. Medial pterygoid - inserts on the medial surface of the mandibular angle and ramus of the mandible.

E. Inferior head of the lateral pterygoid - inserts on the condyloid process.

F. Temporalis - inserts on the coronoid process.

1.2 Fractures of the mandible.

1.2.1 Etiology

There is a striking contrast in the etiology of mandibular fractures both in developed and developing countries. The most common causative factor in developing countries is road traffic accidents (**Rangaswamy *et al.*, 2016).**

This may be due to rash driving and over speeding, below par roads, unwilling to use safety measures such as helmets or seatbelts, inadequate implementation of traffic rules, drunken driving, increased use of motor vehicles by minors, poor maintenance of vehicles, etc (**Chrcanovic *et al.*, 2012).**

The second most common cause was falls. This may be due to variety of reasons such as occupations at elevated heights or other hazardous working conditions and falls from stairs or on wet/slippery, uneven surfaces and bathrooms. In certain patients, falls may be due to medical conditions, decreased tendency to travel by roads, lack of geriatric care, or due to senility **(Shah *et al*., 2019).**

Furthermore, in geriatric patients, bones become more brittle and have a susceptibility to injuries even after minor falls. This condition becomes worse with poor muscular control and bodily response (**Manodh *et al*., 2016).** The third next cause is assault. Assault may be due to aggressive behavior, peer pressure to perform better, unemployment, social inequality, alcohol or drug abuse, and low standard of living. Drunk driving or assault due to alcohol consumption is less in Gujarat because of policy of prohibition (**Weihsin *et al*., 2014).**

The series of single fracture site from most common to least common was dentoalveolar fractures (26.4%), parasymphysis (12.3%), body (10.5%), angle (8.7%), condyle (6.5%), symphysis (4.3%), and ultimately ramus (1.1%) **(Shah *et al*., 2019).**

Table 1: Relation of age group and etiology of fractures **(Shah *et al*., 2019).**

Age group	Etiology					Total
	RTA	Falls	Assault	Sports	Others	
<10	2	5	1	0	1	9
11-20	14	19	5	3	0	41
21-30	58	26	27	3	0	114
31-40	28	17	6	0	1	52
41-50	17	9	4	0	0	30
51-60	7	6	5	0	0	18
61 or above	6	4	3	0	0	13
Total	132	86	51	6	2	277

RTA=Road traffic accident

1.2.2 Fractures classifications based on anatomic site

1.2.2.1 Mandibular body

Fractures of the mandibular body include fractures of the symphysis/parasymphysis and horizontal branches. The symphysis/parasymphysis area corresponds to the region between the two canines **(Nardi *et al*., 2020).**

To simplify our analysis, the generic term symphysis refers to both the symphysis and parasymphysis areas **(Cornelius *et al*. ,2020).**

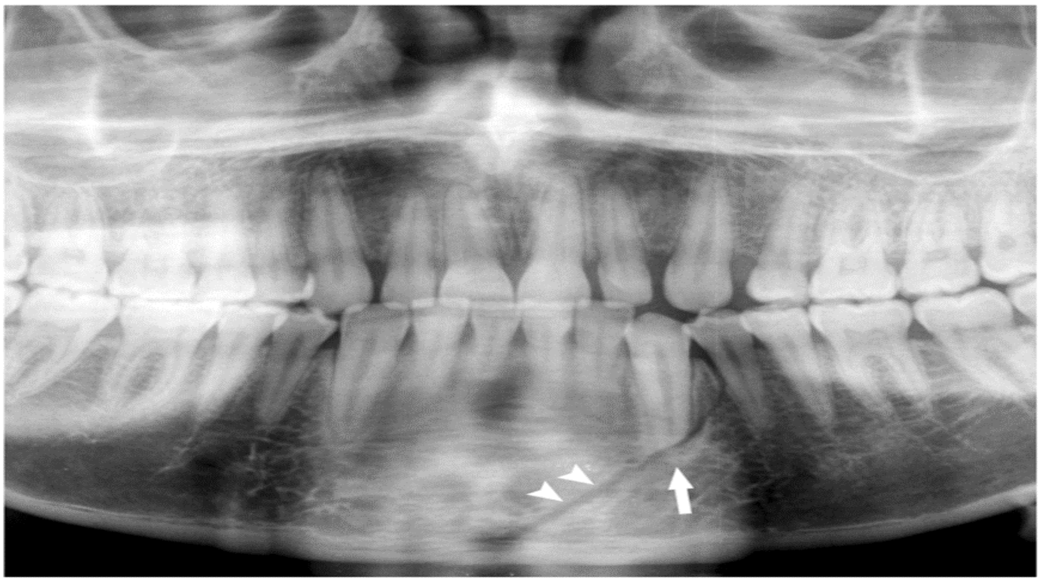

figure 1: symphysis fracture, panoramic radiograph (***nardi et al*., 2020).**

1.2.2.2 Mandibular angle

Mandibular angle fractures occur in a triangular area included between the anterior edge and the postero-superior insertion of the masseter muscle **(Nardi *et al*., 2020).**

These fractures are distal to the third molar and are often found in cases of personal aggression**,** predisposing causes of mandibular angle fractures are represented by impacted wisdom teeth and conditions leading to a thinning/weakening of the mandible such as lytic lesions (cysts or tumors), osteoporosis, osteomyelitis, congenital hypoplasia, and toothless jaws **(Holt,2012)**.

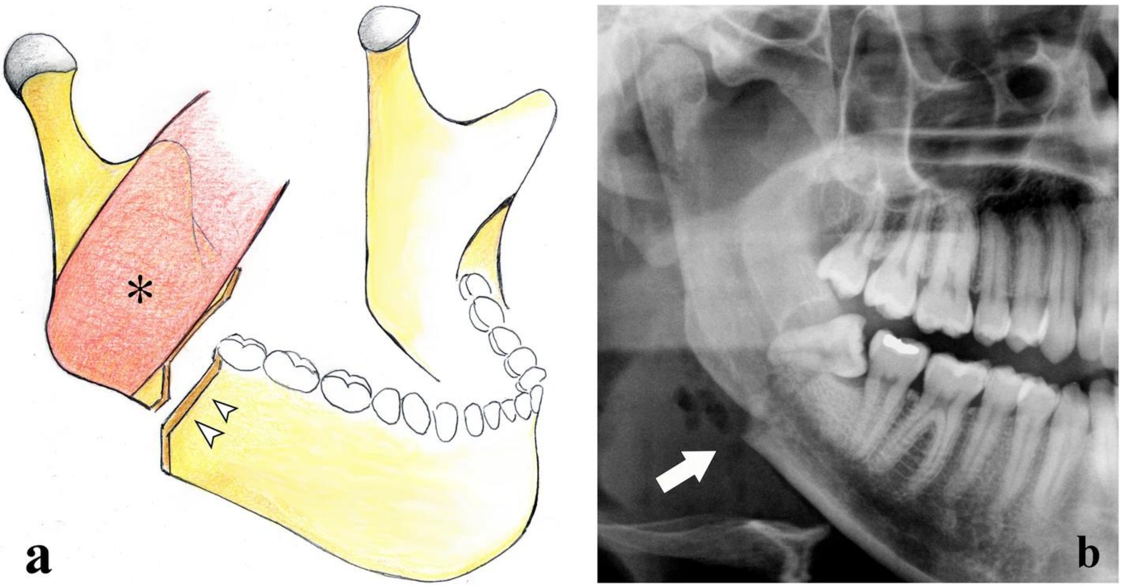

Figure 2: Angle fracture.(**a**) Picture showing a vertical fracture. (**b)** panoramic radiograph, mandibular angle fracture involving an impacted third molar (**Nardi *et al*., 2020).**

1.2.2.3 Mandibular ramus

Fractures of the mandibular ramus are commonly not solitary and are almost always due to direct and violent trauma, the fracture rhyme can have different directions, although it usually has a horizontal course. There are few classifications of mandibular ramus fractures are divided into vertical, horizontal, and combined fractures **(Naeem *et al*.,2017).**

A. Vertical fracture: The fracture rhyme originates from the external face of the ramus and ends at the sigmoid notch.
B. Horizontal fracture: The fracture rhyme runs from the external face to the internal face of the ramus.
C. Combined fracture: Both vertical and horizontal fractures are found.

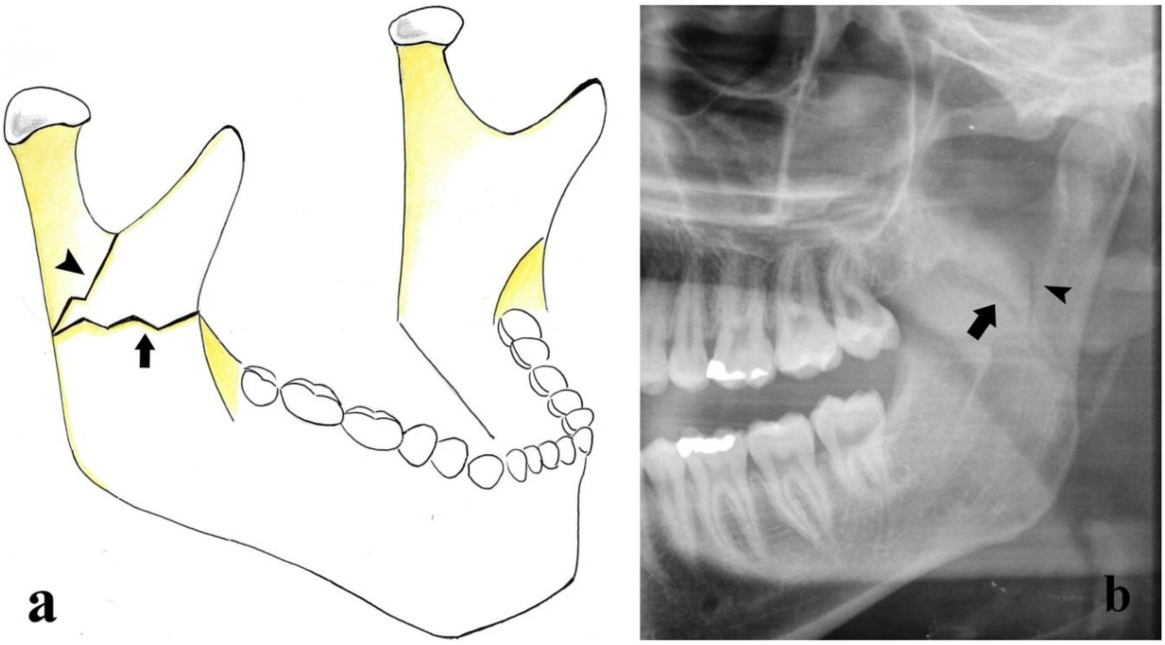

Figure 3: Ramus fractures.(**a)** Picture showing that the mandibular ramus fracture can be vertical (arrowhead) or horizontal (arrow).(**b)** panoramic radiograph, combined fracture of the left mandibular ramus (**Nardi *et al*., 2020).**

1.2.2.4 Coronoid process

The coronoid process rarely faces fracture because it is well protected by several bone structures, especially the zygomatic complex. An isolated fracture of the coronoid process should be seen with suspicion and other concomitant mandibular fractures should be investigated **(Philip *et al*.,1999).**

Based on the position of the fracture rhyme, the coronoid process fractures can be classified as follows:

A. Coronoid process apex fracture.
B. Coronoid process fracture medial to the deepest central point of the sigmoid notch.
C. Coronoid process fracture corresponding or lateral to the deepest central point of the sigmoid notch.

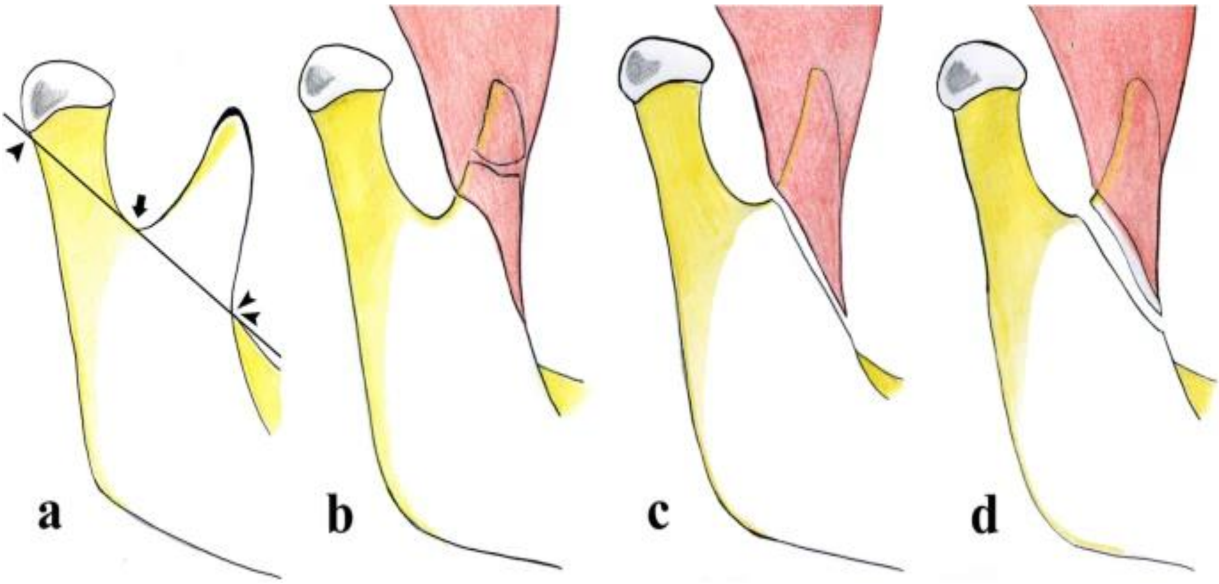

Figure 4: Coronoid process fracture. (**b**) Coronoid process apex fracture.(**c)** Coronoid process fracture medial to the deepest central point of the sigmoid notch points.(**d** Coronoid process fracture lateral to the deepest central point of the sigmoid notch (**Nardi *et al.*, 2020).**

Coronoid process apex fracture is the most common coronoid process fracture. It is fully included in the temporal muscle tendon and the bone fragments are infrequently displaced, whereas the other two types of coronoid process fracture are submuscular fractures and therefore are more susceptible to induce a displacement of bone fragments **(Naeem *et al*.,2017).**

<u>1.2.2.5 Condylar process</u>

There is no univocal consensus among authors on the classification of condylar fractures that should be used both the classifications given by the AO Foundation and MacLennan et al in a radiological report for an efficient and easily understandable subdivision of condylar fractures **(Powers,2017).** The AO Foundation's classification describes the fracture location, it divides the condylar fractures into three groups: head, “high-neck” and “low-neck” fractures. The distinction between high- and low-neck can be achieved by drawing some lines on the image, as detailed below:

A. The first line runs tangent to the posterior edge of the condylar head and mandibular angle.
B. The second line runs perpendicular to the first one passing through the sigmoid notch.
C. The third line, perpendicular to the first one, passes through to the low
D. The fourth line is in the middle between the second and third lines.

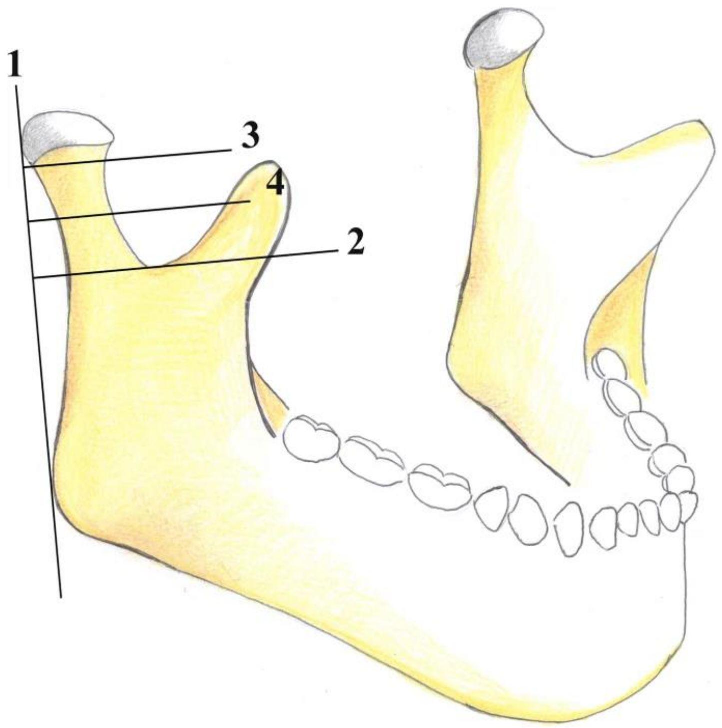

Figure 5: Picture depicting mandibular condyle fractures in according with the AO Foundation’s classification. A fracture is considered “high-neck” and “low-neck” when it is above and below Line 4, respectively **(Nardi *et al*., 2020).**

MacLennan et al.'s classification describes the displacement of bone fragments as follows:

A. No deviation (no bending).
B. Deviation (bending): A fracture where contact between the two bone fragments is preserved.
C. Displacement: The condylar head remains within the glenoid fossa; nevertheless, a loss of contact between the bone fragments is found.
D. Dislocation: The condylar head comes out of the glenoid fossa.

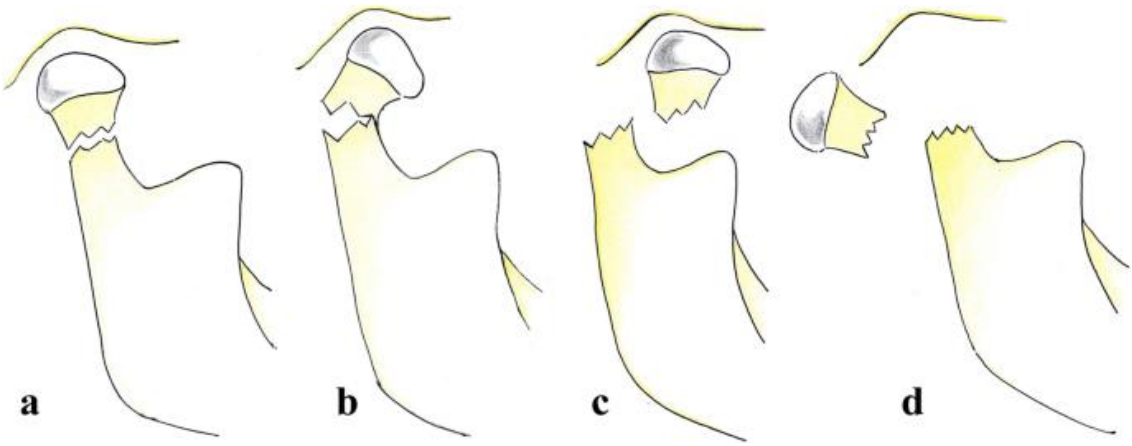

Figure 6 :(**a)** No deviation. The bone fragments are in line and close to each other.(**b)** Deviation, a contact between the two bone fragments is observed but they are not in line.(**c)** Displacement, the condylar head remains within the glenoid fossa but there is no contact between the two bone fragments.(**d)** Dislocation, the articular relation between the condylar head and glenoid fossa is lost **(Nardi *et al*., 2020).**

- ❖ The condylar neck is the weakest area of the mandible, it responds to the need to defend the middle cranial fossa from the traumatic energy that would be transmitted to it by the mandibular condyle,the interruption of the traumatic energy at the site of the condylar neck is a means of defence for the endocranium (**Nardi *et al*., 2020).**

- ❖ In fact, only few cases of glenoid fossa fractures and endocranial dislocation of mandibular condyles have been described, the fracture of both condylar necks is common when the trauma is applied to the chin symphysis **(Powers,2017).**

- ❖ Condylar head fractures are rarer than condylar neck fractures. Condylar head fractures are due to a direct trauma from the bottom to the top on the mandibular angle, which causes crushing of the condyle on the temporal bone (**Nardi *et al*., 2020).**

1.3 MANHAGEMENT OF MANDIBULAR BONE FRACTURE

1.3.1 GENERAL EXAMINATION

Complete history trauma should be obtained after cardiopulmonary and vital neurological functions of the patient are stabilized. Checking the airway by securing cervical spine is vital before assessment. Depending on the consciousness or neurologic status of the patient, history can be obtained from the patient or accompanying family members. Assessments including time, cause of trauma, pain, function of cranial nerves and altered sensation, visual changes, malocclusion, and general systemic conditions should be noted. Some mandibular fractures accompanying multiple injuries, as in traffic accidents, frequently require trauma team**(Guhan *et al*.,2019).**

1.3.2 CLINICAL EXAMINATION

A neurologic examination is a vital point in the assessment of maxillofacial trauma. Functions of cranial nerves such as altered sensation, pupillary reflex, visual changes, and extraocular movements should be evaluated. Motor function of facial expression (nerve VII), symmetrical tongue movements, and mastication muscle (nerve V) should be checked. Sensation of the face should be also noted. The mandible should be carefully evaluated by extraoral palpation. Mandibular contours such as ramus, lateral and inferior borders, and symphysis and parasymphysis area should be checked, and continuity of the mandibular bone should be noted. Movements of fragments can be evaluated by bidigital palpation. Ecchymosis and crepitation should be assessed. Check mandibular movements. Deviations and restriction of movements should be evaluated considering condylar trauma. Also the condylar head should be evaluated by palpation to check if it is in the articular fossa or not. Mucosal laceration, oral bleeding, ecchymosis, and sublingual hematomas should be checked by the intraoral inspection. Rule out fresh oral bleeding in the sublingual space or bilateral symphysis fracture to secure airway, especially for anticoagulant drug users. Examination of the occlusion including loose, fractured, or missing teeth should be performed carefully**(Guhan *et al.*,2019).**

There are two methods to assess mandibular fractures clincally :

<u>1.3.2.1 Bimanual Palpation</u>

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 anteroposterior direction, to elicit abnormal mobility (Figure 7) **(Anshul,2021).**

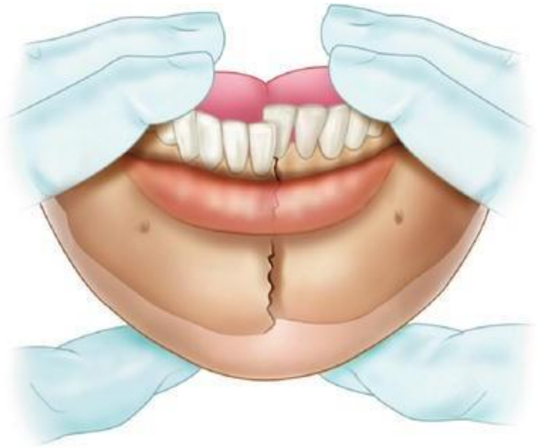

Figure 7: Bimanual Palpation**(Anshul J Rai,2021)(Borle *et al*.,2014).**

1.3.2.2 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 (Figure8)**(Anshul,2021).**

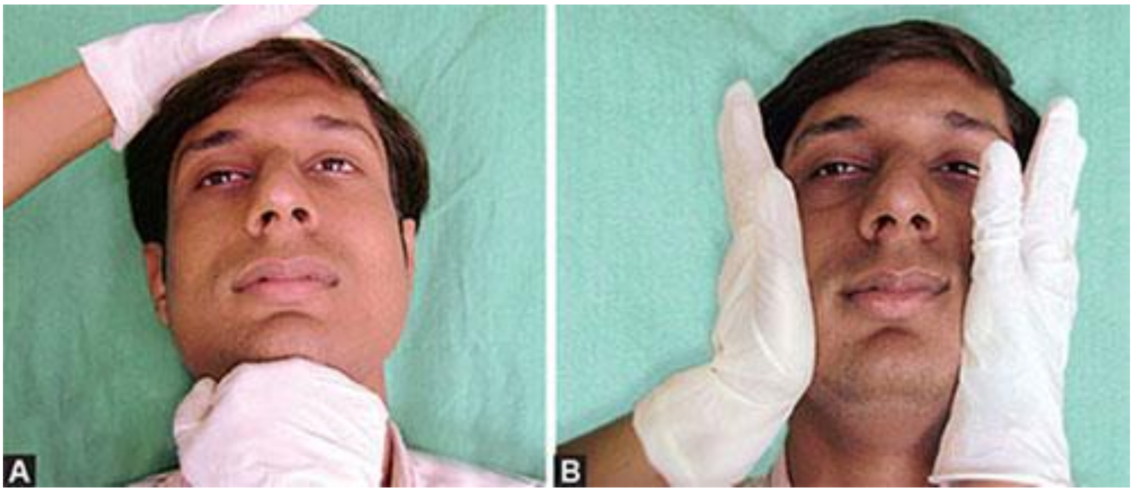

Figure 8: A,B vertical and horizantal compression test**)(Borle *et al*.,2014).**

1.5 RADIOGRAPHIC EVALUATION

Proper treatment of fractures of the mandible is dependent on proper diagnosis of the injury. Paramount in diagnosis of the details of the fracture and therefore the treatment options is the radiographic evaluation. Radiologic evaluation of the cervical spine (C-spine) may be the most important part of the radiologic workup in the evaluation of mandibular trauma since it influences the options for evaluation of the mandible**(Warren,2002).**

In most cases clinical examination cannot be sufficient to intensively evaluate the entire fractures lines, displaced small fragments, root fractures of teeth, and neighboring anatomical structures **(Guhan *et al*.,2019).**

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 **(Anshul,2021).**

The most common radiographs to detect fracture of the mandible are :

A. Orthopantomograph (OPG)—in this radiograph the whole mandible is unfolded on one film.
B. Posteroanterior 10°—it shows the whole mandible including the ascending ramus on each side without superimposition of the mastoid process.
C. Lateral oblique - both right and left—this will not be necessary if OPG is available.
D. Anterior-lateral oblique—to show the horizontal from canine to second molar.
E. Posterolateral oblique will show the condylar head, neck and ascending ramus and the posterior molar region of the mandible.
F. If required CT scan can be done **(Geeti,2009).**
G. A new three-dimensional imaging technique called cone beam computed tomography (CBCT) has proved to supply an excellent

volumetric study of maxillofacial bone structures and satisfactorily recognise mandibular fractures**(Cosimo *et al.*,2020).**

H. MSCT must inevitably be recommended in multiple traumatised patients**(Nardi *et al*.,2017).**

❖ Radiography represents the first level imaging technique in patients with traumatic injury of the mandible. a postero-anterior view, generally used for angle and ramus fractures , an angled antero-posterior view called reverse Towne view useful in case of displacement of condylar fragments , bilateral oblique view used to analyse the angle and horizontal branch of the mandible**(Cosimo *et al*.,2020).**

❖ Panoramic radiography (PAN) is a zonography of upper and lower jaws. It has much higher sensitivity than the three a forementioned X-ray view series for the detection of mandibular fractures (70–92% and 66%, respectively)**(Chacon *et al*.,2003).**

❖ Both PAN and X-ray views are affected by the typical disadvantages of two-dimensional imaging The reason that why two-dimensional imaging of mandibular fractures is usually limited to isolated lesions are difficulty in the patient's positioning, anatomic noise, superimposition, geometric distortion, X-ray angulations, and radiographic contrast—and may be burdened by the slight movements of the mandible, resulting in artefacts**(Nardi *et al*.,2018).**

❖ CBCT has a high spatial resolution (0.075–0.4 mm isotropic voxel) , delivers relatively low radiation doses compared to MSCT , and is only slightly affected by metal artefacts, which often occur in patients stabilised by immobilisation techniques that use metallic materials during post-treatment follow-up**(Cosimo *et al.*,2020).**

❖ Multislice spiral computed tomography (MSCT) represents the reference survey in complex fractures because it benefits from thinlayer thicknesses (0.5–1.0 mm), native images, and three-dimensional multiplanar reformat reconstructions with no overlap between the different anatomic structures. MSCT has sensitivity around 100% in the detection of mandibular fractures**(Naeem *et al*.,2017).**

- ❖ MSCT has a short scan time, allows better image quality for the soft tissue visualisation, and can be used for contrast-enhanced examinations**(Nardi *et al*.,2017).**
- ❖ Magnetic resonance imaging (MRI) is considered to be the best technique for soft tissue evaluation in condylar fractures since it can accurately identify any post-traumatic alteration of the structures that make up the temporomandibular joint, especially the displacement of mandibular condyles**(Zheng *et al*.,2016).**
- ❖ MRI is ideal for determining the increase in the amount of extracellular water in bone marrow oedema, whereas MSCT allows high-quality study of the cortical bone**(Cosimo *et al*.,2020).**

1.6 Signs And Symptoms

A. Generally mandibular fractures result in the rapid swelling around the fracture site. This may be associated with skin ecchymosis.

B. Mandibular fractures are usually compounded into the mouth through the periodontal membrane and therefore there is blood-stained saliva dripping from the corners of the mouth.

C. Due to the bleeding in the oral cavity there is marked foetor-oris when sufficient time has elapsed to allow the multiplication of pathogenic and saprophytic organisms.

D. There may be obvious deformity of bony contour and if there is more displacement the deformity can be palpated and crepitus elicited.

E. If displacement has occurred the patient is unable to close the anterior teeth together and the mouth hangs open.

F. The inferior alveolar nerve is usually injured causing reduced or absence of sensation on one or both sides of the lower lip (paresthesia).

G. The buccal and lingual sulci can show ecchymoses. Bleeding in the lingual submucosa is one of the most valuable signs of bony injury in the body of the mandible (Coleman's sign) (Figure9).

H. Occlusal plane of the teeth will show step deformity and therefore there is deranged occlusion (step deformity)**(Geeti,2009).**

Figure 9: Sublingual hematoma (Coleman’s sign)**(Krishnaveni *et al*.,2015).**

1.7 TREATMENT

1.7.1 Treatment goals for mandibular fracture

a. Anatomical restitution

b. Immobilization

c. Prevention of postoperative complications

d. Rehabilitation of Functions**(Anshul,2021).**

1.7.2 PERIOPERATIVE MANAGEMENT

Displaced fractures that extend through the tooth-bearing region of the mandibular arch often benefit from temporary stabilization of the fracture before ORIF**(Michael *et al*.,2011).**

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 . Initial stabilization and immobilization is done by:

A. Bridle wiring : 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 (figure 9) **(Anshul,2021).**

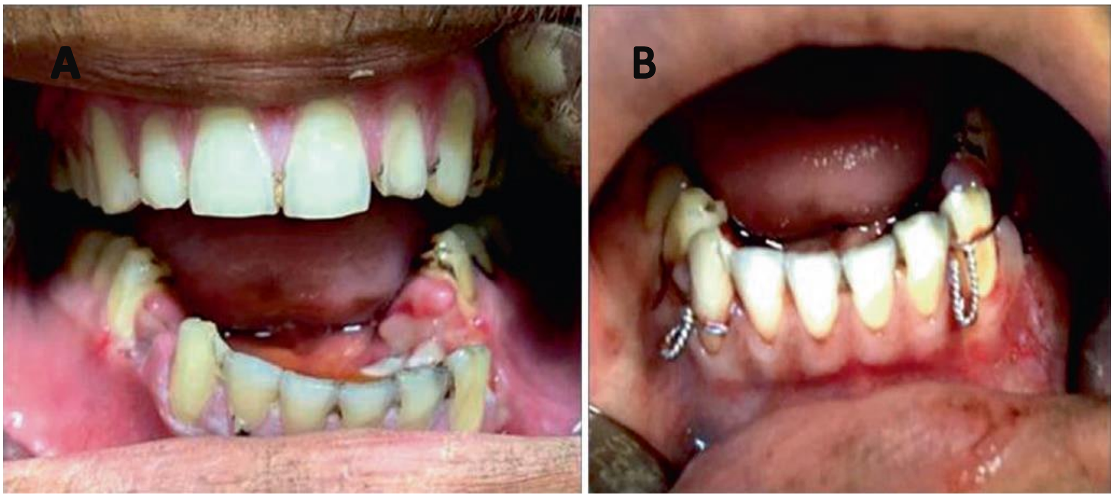

Figure 10: (**A**,**B**) Temporary stabilization of a grossly displaced bilateral body fracture by bridle wiring**(Anshul,2021).**

B. 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 (Figure11)

(b) Four-tailed bandage (Figure11)**(Anshul,2021).**

Figure 11: A- Barrel bandage,b- Four-tailed bandage**(Anshul,2021).**

The administration of antibiotics should begin as soon as possible for all mandibular fractures that extend through the tooth-bearing regions. Preoperative antibiotics have been shown to significantly reduce the incidence of postoperative infections**(Michael *et al*.,2011).**

The two most commonly used preoperative antibiotic agents, clindamycin and amoxicillin, had similar postoperative infection rates (12.8 and 11.8%, respectively, p = 1.00) and were similar to the overall infection rate with any preoperative antibiotics (10.2%)**(Anderw *et al*.,2017).**

1.7.3 TREATMENT PLANNING

Once fractures are diagnosed and evaluated it is to be decided what fixation method should be used after reduction as there are multiple choices available in each of the techniques of:

A. Closed Reduction and Fixation
B. Open Reduction and Fixation
C. External Pin Fixation**(Geeti,2009).**

1.8 Closed Reduction and Fixation

1.8.1 DEFINITION: Closed reduction implies fracture reduction without opening skin or mucosa. Closed reduction of mandible fractures has become synonymous with intermaxillary fixation (IMF) over time (effected generally with arch bars and stainless steel wires). Several other ways have been advocated, for example, Ivy loops, direct wiring **(Cavaillon *et al*.,1988).**

Cap splints, maxillomandibular fixation (MMF) with intraoral bone screws , Gothingham Quick arch bars. and Dimac wires**(Divis,1992).**

A closed procedure , external pin fixators may be used as a closed method, because the fracture is not opened during pin placement alone **(Honig,1991).**

1.8.2 Advantages And Disadvantages

<u>Advantages</u> :-

A. Inexpensive only stainless steel wires needed (usually arch bars also) available .

B. Convenient short procedure or limited operating room time relatively stable .
C. Gives occlusion some " leeway " to adjust itself generally easy .
D. No great operator skill needed biologically conservative .
E. No need for surgical tissue damage no foreign object or material left in body no operating room needed in most cases .
F. Possible outpatient treatment callus formation (secondary bone healing) allows bridging of small bone gaps **(Bertrand,1998).**

Disadvantages **:-**

A. cannot obtain absolute stability (contributing to nonunion and infection) .
B. noncompliance from patient due to long period in maxillomandibular fixation loss of patients to follow-up .
C. difficult (liquid) nutrition complete oral hygiene impossible .
D. possible temporomandibular joint sequelae muscular atrophy and stiffness denervation of muscles alteration in fiber types myofibrosis changes in temporomandibular joint cartilage .
E. weight loss irreversible loss of bite force .
F. decrease range of motion of mandible .
G. impaired pulmonary function, may be problematic for patient with facial trauma patient with premorbid pulmonary condition risks of wounds to operators manipulating wires**(Bertrand,1998).**

1.8.3 Techniques

In patients with teeth bearing fractured segments**(Geeti,2009).**

• IVY loop or interdental eyelet wiring.

• Continuous multiple loop wiring.

• Direct wiring.

• Arch bar fixation.

• Risdon wiring.

In edentulous patients**(Geeti,2009).**

• Circumferential wiring with splint **.**

For inter maxillary fixation (IMF): It is accepted that when the teeth of a fractured jaw are fixed in correct occlusion, the bone fragments supporting them will be satisfactorily reduced **(Geeti,2009).**

1.8.3.1 In patients with teeth bearing fractured segments

A. IVY loop or interdental eyelet wiring: Eyelets are prepared with the help of 24 gauge wire. Both the free ends are passed through the interdental space of firm teeth from thebuccal to the lingual/palatal aspect. Thenthe free ends are brought buccally, one fromthe distal side of the distal tooth and one from the mesial side of the mesial tooth. One of the free ends is then passed through the eyelet and twisted together with the other wire, cut and tucked away. This way multiple eyelets are placed in the maxillary andmandibular teeth. These eyelets in turn are used for intermaxillary fixation(Figure10)**(Geeti,2009).**

B. Continuous or multiple loop: An eyelet made of 24 gauge wire is passed through the interdental space from the buccal to the lingual/ palatal side. Then the free ends each is passed separately through the interdental spaces. One mesial to the mesial tooth and the other distal to the distal tooth.The distal wire is then passed through the eyelet and is laid along the buccal surface of the teeth (a pliable rod approx. 3 mm diameter is placed over the buccal wire). While the other is passed around the buccal wire and back through the same interdental space.

This wire is then passed similarly through other interdental spaces creating multiple loops. The rod is removed and the multiple loops are twisted each 2-3 times. Both the wire ends are then twisted, cut and tucked away. These multiple loops are then used for IMF **(Geeti,2009).**

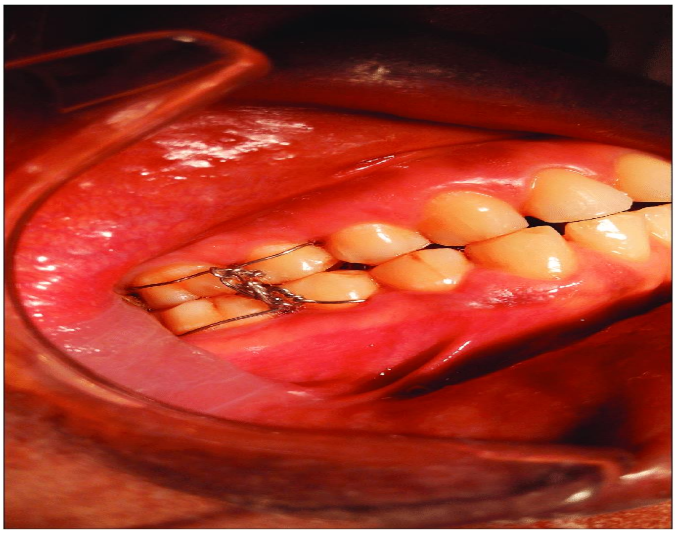

Figure 12: Patient with upper and lower eyelet interdental wires with tie wire in place **(Mark *et al*.,2019).**

C. Direct wiring: Wires are passed around the necks of teeth and the two ends twisted together. These in turn are twisted with thosen twisted wires of the opposing jaw, thus IMF is achieved. This is the simplest wiring technique but its disadvantage is that if for any reason IMF needs to be opened the whole wiring will have to be repeated **(Geeti,2009).**

D. Arch bar: This technique is well adapted even in those patients who have some missing teeth in the oral cavity. An arch bar (Erich's) cut to a suitable length extending distally to first molar on both the sides. The cut ends are bent into the interdental space. Care is to be taken that the hooks are facing upwards in the maxillary arch and downwards in the mandibular arch. A 26 gauge wire is then taken and passed through the interdental space of a tooth from buccal to lingual side above the arch bar then circling the tooth it is brought out buccally from the other interdental space below the arch bar, the two ends are tightened, cut and tucked. Care should be taken not to occupy the hooks of the arch bar. This way the arch bar is tied to all standing teeth. The hooks of the arch bar are used for intermaxillary fixation(Figure13)(**Geeti,2009).**

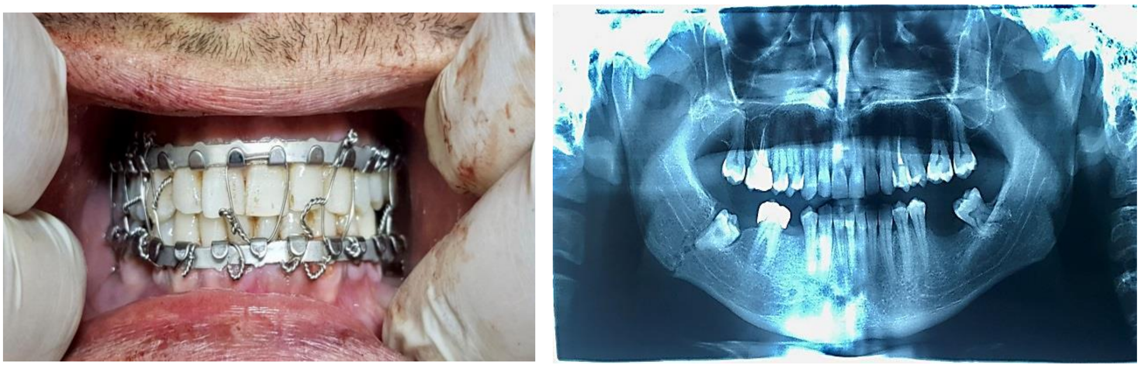

FIGURE 13: use of arch bar in IMF to patient with right angle fracture**(kadhimiya teaching hospital,2021).**

E. Risdon wiring: If an arch bar is unavailable a single suitable length of 1 mm soft stainless steel is passed around the posterior tooth on each side. The ends of these wires are then twisted on the buccal side. These twisted wires are brought in the midline, where they are in turn twisted together. The teeth are then secured to this twisted arch bar and the cut ends of the securing wires tucked in a way that they form hooks. IMF is done with the help of the wire hooks**(Geeti,2009).**

<u>1.8.3.2 In edentulous patients</u>

Circumferential Wiring

This is a technique in which prestretched wires are passed around sound bone and also over the splint (that could be made of metal or acrylic) and tightened. Therefore, the fractured segment does not have any mobility during the period of healing, as it is tied to the firm splint. For fracture of the mandible circum-mandibular wiring is done(Figure14) **(Geeti ,2009).**

Figure 14: Surgically performed circum zygomatic and circum-mandibular wiring **(Satya Prakash Shah et al,2018).**

1.8.4 Period Of Immobilization

The period of immobility traditionally has been 6 weeks for uncomplicated mandibular fractures treated with closed reduction. Research has shown, however, that for healthy, young adult patients, a period of 3 to 4 weeks is adequate. Children require even shorter periods of immobility, and satisfactory healing occurs in most fractures within a 2-week period. Elderly patients were shown to require slightly longer periods 5 or more weeks. Age-related changes in healing capacity and concomitant medical conditions may impact this age group. Fracture site has no significant relationship with regard to healing time and period of immobility necessary, with the exception of the ramus area. When considering the anatomy and thick muscle envelope in this area, it is unlike other areas of the mandible, which is most likely the contributing factor to the slightly shorter immobilization period for ramus fractures **(Meredith&Kurt,2009).**

1.9 Open Reduction and Fixation

1.9.1 DEFINITION: Open reduction implies an opening of skin or mucosa to visualize the fracture and effect the reduction of the bone fragments. This is also limited to techniques in which a significant amount of opening is done (i.e., excluding external fixators with their small incisions) **(Ellis&Tucker,1991).**

1.9.2 Advantages And Disadvantages

Advantages :-

A. Early return to normal jaw function normal nutrition normal oral hygiene after a few days avoidance of airway problems can get absolute stability.
B. Promotes primary bone healing bone fragments reapproximated with exactitude by visualization.
C. Avoids detrimental effects to muscles of mastication does not require patient's compliance or supervision permits the institution of physical therapy early postsurgically .
D. Avoids maxillomandibular fixation for patient with occupational benefits in avoiding mandible fixation (e.q, lawyers, teachers, salespeople) , seizure disorders , potential airway problems special nutritional requirements (diabetics, alcoholics) , psychiatric disorders need for oral access (for example in intensive care unit patients) .
E. Decreased patient discomfort .
F. Greater patient satisfaction , less myoatrophy decreased hospital time , substantial savings in overall cost of treatment when the cost of complications is also considered .

G. Lower risk of major complications , lower infection rates , lower rate of malunion/nonunion**(Bertrand,1998).**

Disadvantages :-

A. Need for an open procedure significant operating room time .
B. Prolonged anesthesia .
C. Expensive hardware .
D. Some risk to neuromuscular structures and teeth need for secondary procedure to remove hardware "unforgiving procedure": the rigidity of the plates means no yielding to eventual intermaxillary fixation or elastic forces if postoperative movements needed.
E. Need much operator skill, therefore human error is frequent .
F. Meticulous technique needed .
G. Directly compared to maxillomandibular fixation higher frequency malocclusion.
H. Higher frequency facial nerve palsy.
I. Scarring (extraoral and intraoral) .
J. Need sophisticated material .
K. No bridging of small bone defect (absence of callus) **(Bertrand,1998).**

1.9.3 Steps in Open Reduction Internal Fixation (ORIF) of Mandible Fracture :-

A. Incision (extra-/intraoral)
B. Exposure of the fracture site (Figure15).
C. Curettage to remove the granulation tissues and irrigation with normal saline.
D. Reduction of the fracture (with the help of bone-holdingforceps) , Chin retractor is also helpful in reduction of fracture fragments.

E. Immobilization with MMF.

F. Fixation with plates and screws.

G. Closure of the incised site.

H. Pressure bandage over the surgical site to avoid postoperative hematoma formation in required cases**(Geeti,2009).**

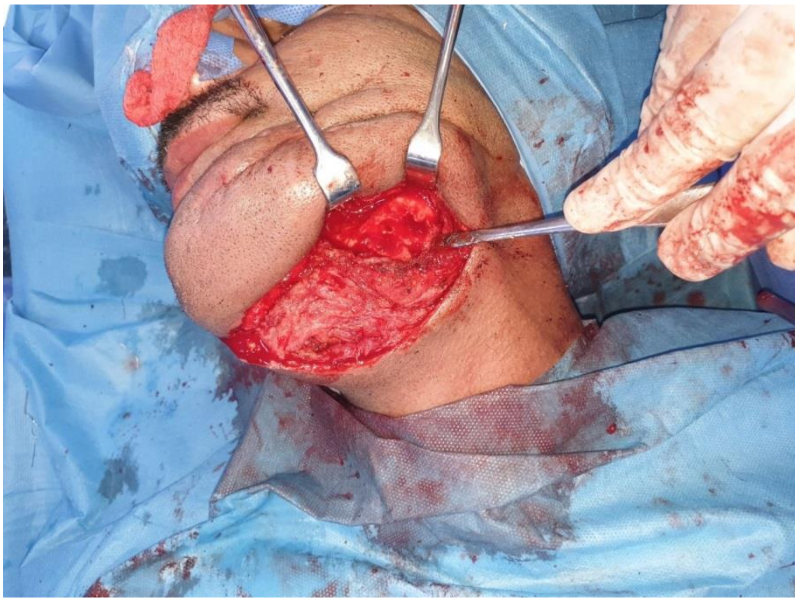

Figure15: Extraoral exposure to the site of fracture in ORIF procdure in the patient with left body of the mandible fracture**(Ghazi Hariri Hospital,2021).**

1.9.4 Techniques

A. Plating

B. Wiring

C. Lag screw

D. Intermedullary pinning

The advantages of open reduction are that the mouth does not require IMF for 5 weeks**(Geeti,2009).**

A. PLATING

If teeth are present, IMF is done; then incision is made and bone is reached either extraorally or intraorally. The fractured ends are approximated and screw holes are made such that atleast two screws can be placed on either side of the fracture. The screw hole is then tapped with a screw tap, using a depth gauge the size of the screw isdecided.

Then a corresponding screw is taken and placed over the tapped bur hole, it is then tightened. Similarly all screws are fixed, this will rigidly fix the bone, sometimes more than one plate is required for rigidity. The surgical site is then sutured in multiple layers.

Different kinds of plates are available:

- Compression plates
- Orthopedic plate
- Mini plates **(Geeti,2009).**

❖ CHAMPY'S PRINCIPLE

Mini plates are applied using the Champy's principle that states— natural line of compression exists along the lower border of the mandible. If plates are applied along this border then mini plates with self-tapping monocortical screws applied on the outer cortical plates after reduction will be enough for proper fixation of fracture of mandible. Plates are fixed on the ideal line of osteosynthesis, known as Champy's line of osteosynthesis(figure16). Therefore, the fractures of the angle of mandible can be secured using a single plate at the upper border on the external oblique ridge. The fracture of the parasymphysis region require two plates just below the alveolus and the other at the lower border. For fracture of the body behind the mental foramen, a single plate is fixed just below the roots of the teeth and above the inferior alveolar nerve**(Geeti,2009).**

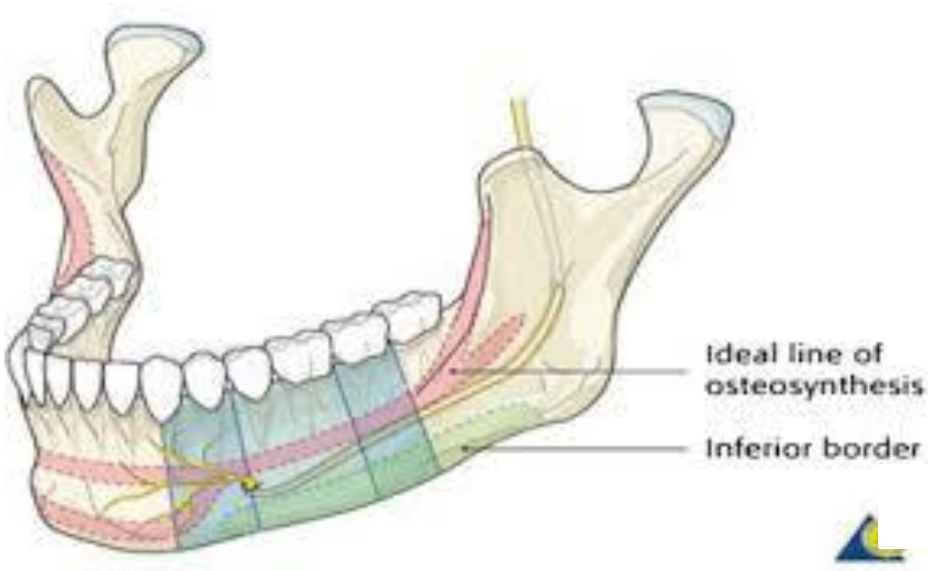

Figure 16: Champy's ideal line of osteosynthesis **(Khiabani&Mehmandoost,2013).**

Surgical Approach

Mini plates are applied using the intraoral or extraoral approach or a combination of both. The reduction of the fractured ends is done. The miniplate is fixed using 4 monocortical screws (These screws engage only the outer cortical plate) placed 2 on each side of the fracture. The length of the screws should be at least 5 mm , The surgical site is irrigated and closed using interrupted sutures**(Geeti,2009).**

B. Wiring

If teeth are present, IMF is done to correct occlusion.Mandible is opened, fractured ends are approximated. Decision is taken on the type of wiring. Bur holes are made which penetrate both the cortii. Wire is passed through and tightened. Once immobilization is satisfactory the incision is suturedn and dressing done**(Geeti,2009).**

C. Lag Screw

This is specially indicated in oblique fracture. The lag screw is a special screw which has threads only on one half, the half near the head of the screw is smooth. Once the fractured ends of the mandible are approximated a bur hole is made obliquely through both the cortii. The hole is threaded with screw top. Depth of the screw is taken with the help of depth gauge. Then a suitable size of lag screw is tightened. As it is screwed further the lingual cortex is pulled towards the buccal cortex by further tightening as the screw has thread only in its first half. This tightening will compress the fractured ends against each other**(Geeti,2009).**

D. Intermedullary Pinning

A 2 mm diameter Kirschner wire or Steinmann's pin is used for intramedullary pinning. It is a useful method in certain cases, e.g.

A. Symphyseal fracture
B. In cases where IMF is contraindicated
C. Unstable fractures
D. Pathological fracture**(Geeti,2009).**

1.10 External Pin Fixation

In patients that have sustained extensive comminution or there is infected fracture, sometimes the major fragments are maintained in their proper relationship by using external pin fixation. In this technique a pair of 3 mm titanium or stainless steel pins are inserted into each major bone fragment. These pins diverge from each other but are connected to a cross bar by means of universal joints**(Geeti,2009).**

1.11 The best treatment techniques for various type of fractures

1.11.1 Symphysis and Parasymphysis Fracture

Fixation with two miniplates is widely used for the fixation of symphysis and parasymphysis fractures. Some authors preferred use of two lag screws 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 . Various fixation techniques for anterior mandibular fracture :

A. Reconstruction bone plates
B. Single strong nonreconstruction bone plate
C. Double miniplates
D. Two lag screws
E. Three-dimensional (3D) plate
F. Segmental arch bar with single large and stronger bone plate **(Anshul,2021).**

1.11.2 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.

Fixation Techniques for Angle Fracture:

A. Wire osteosynthesis (obsolete).
B. Single miniplate on the superior border.
C. Single plate on inferior border.

D. Two plates, one at superior and another on inferior border.

E. Lag screws.

F. Three-dimensional plates**(Anshul,2021).**

1.11.3 Body Fracture

A single four hole with gap miniplate 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 extraoral soft tissue injury/scar or having severely comminuted fracture fragments**(Anshul,2021).**

1.11.4 Ramus Fracture

Mandibular ramus (MR) fracture occurs rarely and ranked third least common fracture after alveolar and coronoid fracture. MR fractures are very rare in isolation. It can be horizontal or vertical. Its incidence ranges from 0.9 to 5.5% . 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 bone**(Subhashraj&Nandakumar,2007).**

1.11.5 Coronoid Fracture

It generally occurs in combination with other fracture of the mandible , and with zygomatic complex fracture (commonly with arch) , 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**(Delantoni&Antoniades,2010).**

It manifests as :

- Swelling below the zygomatic arch
- Ecchymosis in the retromolar trigone area
- Restricted mouth opening, malocclusion, and facial collaps when occurs in association with other facial fractures**(Philip *et al*.,1999).**

Indications of closed and open reduction for coronoid Fractures Conservative:

- Minimal displacement
- ORIF Significant fracture displacement and Limited mouth opening Associated with zygoma, zygomatic arch,mandibular ramus
- Patients who are bad candidates for MMF**(Anshul,2021).**

1.11.6 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 . ORIF is the treatment of choice most of the times**(Ellis&Walker,1999).**

1.11.7 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**(Finn,1996).**
- 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). To fix small fragments, multiple options are mentioned inthe literature like miniplate, microplate, screws, steel wires, and absorbable

sutures. A fragment larger than 1 cm should be conserved, reduced, and fixed**(Li,2011).**

- 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 **(Ellis *et al*.,2003).**
- Implants used for fixation of comminuted fractures are mentioned in Use of reconstruction plates required expertise and it is time-consuming. Sometimes contour. Sometimes contour is also not favorable which can create slight malocclusion but can be managed by postoperative elastics and selective occlusal adjustments . 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**(Dia *et al.*,2016).**

Multiple miniplates

A. Reconstruction plates
B. Combination of mini- and reconstruction plates
C. Titanium Mesh **(Anshul,2021).**

1.11.8 Guards Man Fracture

Describes such trauma. The syncope of the long standing solider leads to a fall and impact at the chin which results in a unilateral or bilateral condylar fractures as well as the symphysis fracture Condylar fractures can be classified according to the anatomical location of the fracture and the degree of dislocation of the condylar head **(Philip,2013).**

Classifications according to Lindahl (1977) Fracture level

A. Intracapsular fracture
B. Conylar neck fractue
C. Subcondylar fracture

- ❖ According to its relationship with the mandible, the condylar fragment is then described and classified as displaced or non-displaced and according to its relationship with the fossa as dislocated or non-dislocated. Unilateral or bilateral condylar fractures could occur. Depending on the degree of injury, displacement of fractured fragments and dislocation of the condylar head . the patient may present with pain, a limited mouth opening, a deviated lower jaw with an open bite. Much more serious complications include fracture of the tympanic plate, mandibular fossa of temporal bone fracture with or without dislocation of the condylar head into the middle cranial fossa **(Lars,1977).**
- ❖ Condylar fractures are treated through surgical open reduction with internal rigid fixation or non-surgical functional therapy through closed reduction with intermaxillary fixation. With advances in osseous synthesis techniques and materials, and the emergence of titanium micro-screws and plates, open reduction and internal rigid fixation is getting more and more common and predictable with less

disturbance to joint function. In closed reduction, the joint function is restored by allowing active mobilisation of the joint after a short period of intermaxillary fixation. The condyle is allowed to remodel. Elastic traction might be necessary to control any occlusal disharmony **(Philip,2013).**

1.12 Prognosis of the teeth in the fracture line

Fractures of the fracture line, excessively displaced, and teeth which have their cement exposed, if they are not to be temporarily held in the mouth to maintain occlusion, must be extracted**(Andreasen,1970).**

The teeth with apical infection and teeth with excessive periodontal defects, teeth with root fractures, and teeth that prevent the reduction of fracture segments should be extracted**(Guhan *et al*.,2019).**

❖ Are Postoperative Radiographs Necessary

The answer is no. The reasons behind this is:

A. More than 100–250 deaths occur worldwide from cancer due to unnecessary radiation from diagnostic radiology as suggested by Royal College of Radiologists**(National Radiologic Protection Board,1990).**

B. If somehow retreatment is required for the patient, it generally depends most commonly on the clinical findings rather than radiographic . The postoperative radiographs are required in few cases of :

- Mandibular fracture treated with closed reduction
- In medicolegal cases to prevent judicial complications
- Patients who enrolled in the research activities**(Durham *et al*.,2016).**

❖ The advantages of avoiding postoperative radiographs are:

- Exposure reduction of patients to ionizing radiation
- Reduced cost
- More efficient discharge**(Anshul,2021).**

1.13 Complication

Complications in the treatment of mandibular fractures occur regularly and, even in the most experienced of hands, should be expected **(Moulton *et al.*,1998).**

The most common complications include ;-

1.13.1 Infection

is the most common complication in patients undergoing treatment of mandibular fractures, occurring between 1% and 32% of the time **(Chacon&Larson,2004).**

Numerous risk factors have been associated with postoperative infection, including substance abuse or patient noncompliance with postoperative regimens (**Passeri *et al.*,1997)** and a significant delay in treatment **(Buchbinder,1993).**

Definitive treatment within 3 to 5 days after trauma has been shown to be optimal in terms of minimizing the rate of infection **(Obwegeser &Sailer,1973**).

Other risk factors include high-velocity injuries and severe comminution, gross contamination, and highvelocity ballistic injury. Most infections related to mandibular fractures are polymicrobial, with both aerobes and anaerobes routinely cultured. The most common organisms are Staphylococcus, alpha-hemolytic Streptococcus, and Bacteroides, as well as gram-negative organisms. Penicillin G (with or without Flagyl depending on gram stain) or clindamycin is the drug of choice. Successful management of the infection requires adequate drainage, removal of the source, and appropriate antibiotic therapy. If the cause of the infection is related to loose hardware and there is favorable bony union, removal of the loose hardware is all that is necessary. In inadequate stability of the fractured segments is apparent, the previously placed fixation should be removed and replaced with more rigid fixation, usually in the form of a locking reconstruction plate. Although careful patient selection is necessary, immediate bone grafting of infected mandibular fractures used in conjunction with rigid internal fixation and appropriate intraoperative débridement can be an effective treatment modality, which allows a single surgical procedure and successful bony union(**Boyne&Upham,1974).**

1.13.2Malunion

occurs typically because the injury complex was particularly complicated, the patient was noncompliant with postoperative instructions, and/or the surgeon violated basic principles of reduction, stabilization, and fixation. The excep-tion to this rule is with regard to closed treatment of mandibular condyle fractures, where malunion is an inherent risk to the procedure itself and malocclusion results in a significant number of patients, even those who are compliant and in whom the procedure was carried out expertly. When malunion occurs, mandibular osteotomies are generally indicated to correct the occlusion and restore facial symmetry/projection**(Edward,2012).**

1.13.3 Nonunion of mandibular fractures

is an uncommon sequelae of treatment, but it may occur even in the most experienced hands. High-velocity injuries resulting in severe comminution, inadequate or improperly placed fixation, and poor patient compliance are common etiologies. Treatment typically involves reoperation with débridement of soft tissue and nonviable bone, followed by stabilization and application of rigid internal fixation with a locking reconstruction plate and immediate bone grafting if necessary**(Benson *et al*.,2006).**

1.14 Inferior Alevolar Nerve Injury Due To Mandibular Fractures

The inferior alveolar nerve is well protected inside the mandibular canal. But, in mandibular fractures, this position of the nerve itself will endanger its integrity , the prevalence of post-traumatic or pre-treatment inferior alveolar nerve dysfunction (IAND) after a mandibular fracture ranges from 5.7% to 58.5%, and IAND after treatment ranges from 0.9% to 66.7%**(Thurmüller *et al.*,2001).**

Clinically, there are various methods to evaluate the presence and degree of nerve injury ,this can vary from just asking the patient subjectively about any neurosensory deficiency to complex clinical neurosensory testing (CNST) **(Coghlan&Irvine,1986).**

1.14.1 Neurosensory Testing

The sensory function of the IAN was tested at diagnosis of a mandible fracture before treatment , and after treatment at 1 week, 6 weeks, 3 months, 6 months and 1 year. The patient was asked if there was numbness without stimulus and on stroking the lower lip skin with a finger. The patient was asked to grade the sensation present on an analog scale from 0 (no sensation) to 10 (completely normal sensation); this form ed the patient-reported neurosensory disturbance (NSD) **(Tay *et al*.,2015).**

In 1992, Zuniga and Essick described a testing algorithm for grading trigeminal nerve injuries using CNST methods.

testing algorithm ; is simple to apply and can be performed chairside with minimal equipment, making it a valuable tool in identifying and grading neurosensory deficits **(Tay *et al*.,2015).**

Neurosensory testing (Table 2, Figure17) included direction sense and 2-point discrimination (Level A), contact detection (Level B) and pain sensation (Level C), as described by Zuniga and Essick (1992) **(Zuniga &Essick,1992).**

Preoperative testing utilized Level A and C (modified) but omitted Level B; the rationale was that Level A detected the presence of at least mild sensory impairment, while Level C indicated a possible significant nerve injury. For Level C testing, a thermode(Figure18) was the instrument of choice; however , a thermode is bulky and expensive, and could not be used if the patient unable to come to the dental clinic. At preoperative testing, a sharp probe was used instead of thermode testing for Level C. Two different sensory modalities (pinprick pain with the sharp probe; temperature pain with the thermode) are being assessed , they can be 'equated' in the sense that loss of either pinprick pain or temperature pain is indicative of severe sensory impairment. Pinprick pain was reported by Zuniga and Essick (1992) as an alternative method to temperature pain for level C testing)**(Zuniga&Essick,1992).**

Temperature pain testing has the advantage of avoiding false positives that may arise from the pressure applied via a sharp probe on the lower lip overlying a fractured mandible. Post-treatment neurosensory testing was performed using the complete Zuniga-Essick protocol as described. From clinical use of this neurosensory testing protocol in nerve injuries from third molar surgery, it is known that early testing with this protocol may indicate a more severe level of sensory impairment than if the testing was performed after 3 months from nerve injury**(Tay *et al*.,2015).**

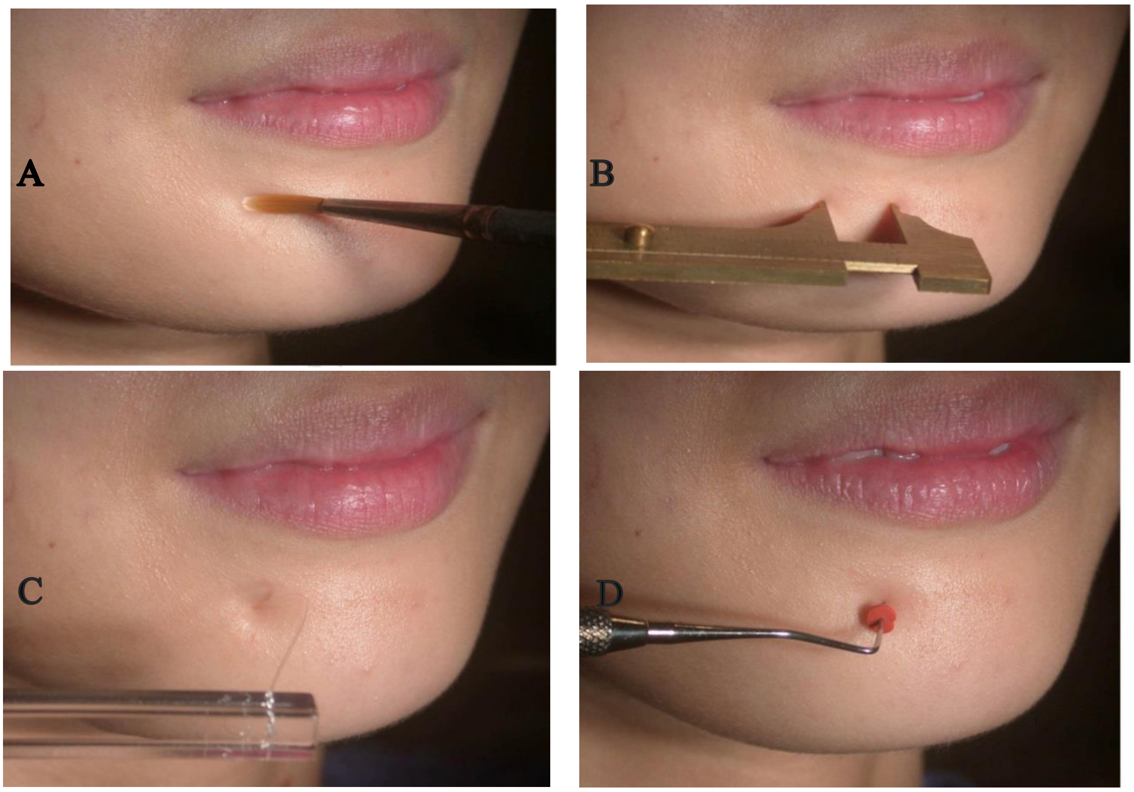

Figure17: Neurosensory Testing(A- Level A: Brush Stroke,B- Level A: 2-Point Discrimination,C- Level B: Contact Detection,D- Level C: Pinprick Pain**(Andrew *et al*.,2015).**

Figure18: Neurosensory Testing(Level C: Thermode)**(Andrew *et al*.,2015).**

Table2: Neurosensory Testing Instructions**(Andrew *et al*.,2015).**

Test	**Method** (Patient's eyes must be closed for all tests)
Sensory analog scale	Stroke both sides; ask patient to quantify how much sensation is present on the test side compared to the normal side (10 = normal, 0 = anaesthesia)
Level A	
Brush stroke direction	Use soft brush to stroke test area 15 times; note the number of times the patient gives correct direction of stroke. Less than 90% correct responses gives an abnormal result.
Static 2-point discrimination	Use modified sliding gauge to determine minimum distance that 2 points of contact is perceived; test in descending order twice for each interval; perform 5 trials, obtain mean of last 4 trials as result. Inability to feel 2 points at interval distance of 12 mm or more gives an abnormal result.
Level B	
Contact detection	Use Semmes-Weinstein fibres; touch until fiber bends, hold for 1s then remove; test in ascending order until sensation for 2 consecutive fibers, record first positive ascending fiber; then in descending order to until sensation for 2 consecutive fibers, record the first negative descending fiber. The mean of the ascending and descending value gives the result. More than 2.83 gives an abnormal result for the lower lip.
Level C	
Pinprick pain	Use a sharp probe to press to a depth of 4 mm, twice in each of 3 regions, one on the vermilion, one on the labiomental fold and one on the chin. Absence of pain in more than 1 out of 6 times is an abnormal result.
Thermal pain	Hold the probe of a Peltier-type thermode (runs the temperature at the probe tip from $35^{\circ}C$ to $50^{\circ}C$ at the rate of increase of $0.1^{\circ}C$ per second) on the test area. Patient to indicate when pain is felt (threshold value) and when pain is unbearable (tolerance value). More than $47^{\circ}C$ for threshold and $50^{\circ}C$ for tolerance gives an abnormal result for the lower lip.

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