Closed reduction for comminuted mandibular fractures

Thaer Abdul Lateef, B.D.S., H.D.D., F.I.C.M.S. (1)

ABSTRACT

Background: Closed reduction and indirect skeletal fixation is a well known modality for treatment of mandibular fractures. The aim of this study was to evaluate this modality as the treatment of choice for comminuted mandibular fractures due to missile injuries.

Materials and methods: This study included 32 patients presented with comminuted mandibular fractures due to missile injury. The patient ages ranged from 21-58 years, 26 of them were males and 6 females. Closed reduction with the use of maxillomandibular fixation for 6 weeks was the modality of choice.

Results: The most common site was the body region 50%, complication rate (transient and permanent) was 53.1% with significant bone loss in 13 patients 35.1%.

Conclusion: Initial conservative treatment found to be effective and the complex hard and soft tissue reconstructions reserved later for definitive approach.

Keywords: Missile injury, comminuted fracture, closed reduction.

INTRODUCTION

Surgeons, because of differences in training and experience prefer some types of treatment over others and it probably matters little what method is used as long as the desired result in treatment of mandibular fractures are obtained, this include the restoration of function of the jaw occlusion of the teeth and normal appearance of the face. Regardless the method or methods employed, certain basic principles must be understood and followed closely in order to ensure the successful completion of treatment, and these include Reduction, Fixation and Immobilization.

Wounding characteristics of missile injuries

The principal mechanism of injury from the low velocity bullet is laceration and crushing of tissue, while the high velocity missile has two additional very important means of causing extensive tissue damage cavitation & production of pressure and shock wave (1). Cavitation develops during the passage of high velocity bullets through tissue. When penetration occurs, there is rapid energy release, a large cavity is formed that reaches its maximal size in only a few milliseconds and may be 30-40 times the diameter of the bullet (2).

Gunshot injuries usually involve multiple types of tissue that vary in their susceptibility to injury. An important variable is the tensile strength of the involved tissue. Bone is the least elastic organ in the body and the most resistant to cavitation, it is also the most severely damaged organ struck by a high-velocity missile (1,3).

A temporary cavity produced in close proximity to bone can cause to shatter and propel many secondary missiles, thereby increasing tissue damage that account for the extensive destructive nature of high velocity missiles (4). The more importance in maxillofacial region is the stress wave caused by the missile, it preceds the cavitation phenomenon, since it moves faster than the speed of sound before cavitation occurs. Fracture of bone away from the wound track is a definite feature of highly energy transfer wounds (5). In dentulous patients the shock wave causes fracture of teeth just below the gingival margin in other parts of the jaw (6).

Comminuted fractures. Mandibular fractures are classified into: simple, compound, comminuted (fractures that characterized by the shattering of bone into multiple fragments at any one fracture site), complicated, impacted, greenstick and pathological (7).

Injuries produced by firearm vary depending on several variables including the size, shape and nature of projectile, the muzzle velocity, distance of the firearm from the body at the time of discharge, the angle of firing and the part of the body involved (8).

Treatment of Mandibular fractures:

Definitive treatment is considered under two main headings:

a) Closed reduction & indirect skeletal fixation (direct interdental wiring, interdental eyelet wiring, continuous or multiple loop wiring, arch bars, cap splints, gunning-type splints and pin fixation).

b) Open reduction & direct skeletal fixation (tansosseous wiring, intramedullary pinning, nylon circumferential strap, bone clamps, bone staples, metallic mesh implants and mandibular plating (7)).

(1) Lecturer, Department of oral and maxillo-facial surgery, College of dentistry, University of Baghdad.
Barber et al., 1997 advocated the use of simplest means possible to reduce and fixate a mandibular fracture by closed technique whenever possible as the open reduction carries an increased morbidity risk. 

**Immobilization**

Maxillomandibular fixation (MMF) is usually used for mandibular fractures. Proper immobilization at the fracture site is a prerequisite for undisturbed healing and ossification of callus. The period of stable fixation required to ensure full restoration of function varies according to the site of fracture, the presence or absence of retained tooth in the fracture line, the age of the patient and presence or absence of infection. In fractures of the body of the mandible the blood supply to the fracture site is significant. Where endosteal vascularity is relatively poor as in the ageeing jaw and particularly in the symphysis region healing to be prolonged. In contrast, the rich blood supply and exuberant osteoblastic activity of the child growing mandible ensures extremely rapid union. Traditionally the length of time for MMF used for immobilization of adult fractures has been 6 weeks.

**Imaging Studies**

The treatment plan for fractures of the mandible is very dependent on the precise radiological diagnosis. Plain radiography and CT scanning help to ascertain the location of the fracture, the degree and direction of displacement and the presence or absence of associated injuries. All of this information is integral in developing an appropriate treatment plan for the patient. CT scanning and plain radiography including panoramic, lateral oblique, posteroanterior, mandibular occlusal, reverse Townes and periapical views may be helpful in diagnosis of mandibular fractures.

CT scanning is generally the best imaging modality in the evaluation of penetrating injury when a retained foreign body is suspected. It is useful in defining the relationships of foreign bodies to surrounding muscles, bones and soft tissues.

Three-dimensional reconstructions of CT scans can be useful to evaluate complex mandibular fractures. The ultimate imaging tool is the stereolithographic model which some centers are able to make from CT scan images. These life-size models of the facial bones can be useful in planning treatment and may be used as templates for contouring rigid hardware or constructing splints and other adjunctive appliances.

**Complications**

Complications are classified under two headings:

1. Complications arising during primary treatment (infection, nerve damage, displaced teeth and foreign bodies, pulpitis, gingival and periodontal complications, drug reaction).

2. Late complications (malunion, delayed and non-union, derrangement of the TMJ, late problems with transosseous wires and plates, sequestration of bone, traumatic myossitis ossificans and scars). Chang et al, 2005 classified mandibular fracture complications into:

   1. Acute complications are the result of trauma itself.
   2. Intermediate complications are caused during MMF.
   3. Late complications occur after MMF.

   Sensory disturbances in the distribution of the trigeminal nerve are common after facial injuries and are due to contusion, stretching, compression or division of nerves concerned. The inferior alveolar nerve is frequently contused, stretched or severed at the time of mandibular injury. Temporary or permanent alteration of sensation around the lips may result.

   Anesthesia of the lower lip as a result of neuropraxia or neurotmesis of the inferior alveolar nerve is the most common complication of fracture of the body and angle of the mandible producing anesthesia or paresthesia within the distribution of the mental nerve on the side of injury.

   Any facial injury demands a complete functional evaluation of the main trunk and its branches before any treatment. Injuries to the mandibular area margins affect the marginal mandibular nerve causing wry mouth. Buccal branch injuries cause inability to smile and loss of nasolabial crease as well as sagging upper lip.

   Injury to the lower part of the face by a high velocity missile commonly result in avulsion of part of the mandible, and in such cases, there is almost always associated loss of soft tissue. The loss of bone in the ramus and proximal part of the body of the mandible is much less a problem than at the symphysis. Every possible effort should be made to bridge the symphysis and to avoid any gaps between the bone ends during the initial surgery and if bone has been irretrievably lost from this area, the two sides of the mandible should be maintained in normal anatomical relationship.
MATERIALS & METHODS

Patients' age & gender
The study discuss and prospectively review the results of 32 dentulous patients derived from population of patients with missile injuries admitted at the oral & maxillofacial surgery department at Al-Yarmouk Teaching Hospital in the period between October 2006 – October 2007. The extremes of patient age ranged from 21-58 years.

Diagnosis
Diagnosis of mandibular fractures based on clinical and radiographic examination. Clinical examination of the face included extra and intraoral examination. The local examination was done to diagnose or exclude the presence of mandibular fractures. Extraoral examination achieved by inspection for the presence of swelling, ecchymosis, bleeding, soft tissue laceration, changes in facial contour, limitation or any abnormal mandibular movements. Bimanual palpation of the mandible with both hands to detect any step deformity, tenderness or crepitation on pressure. Compression test was used by the application of gentle compression of the mandible using both hands in two opposite directions under the lower border to elicit pain which indicate mandibular fracture.

Intraoral examination was started by inspection for the presence of sublingual hematoma, mucosal lacerations and changes in occlusion. Teeth were examined for quantity, quality and occlusal relationship, gentle manipulation for mobility of fractured segments and displacement.

Radiographic examination include the essential radiographs and according to their availability (plain radiographs as posteroanterior view of the mandible, oblique lateral view, intraoral occlusal view), Panoramic view OPG as shown in (Figure 3 and 4), computed tomography CT scans (axial and coronal).

Maxillomandibular fixation MMF
Closed reduction and indirect skeletal fixation the sole method of treatment, with jaws fixed using arch bars (Erich pattern) as a mean of intramaxillary fixation for the maxilla and mandible (Figure 2), MMF was carried out with soft stainless steel wires (0.35 mm gauge or 0.4 mm) for all patients. Circumferential wiring used in two cases only for support and elevation of badly displaced mandibular fractures. Immobilization for 6 weeks being the general guideline. Reduction and fixation of comminuted mandibular fractures achieved in 25 cases under local anesthesia and in 7 cases under general anesthesia. All patients were placed on antibiotic treatment (prophylactic or therapeutic for already present infection) with possible use of culture and sensitivity test if possible from the time of admission until five days postoperatively. Osseous union of the fracture was tested clinically after 6 weeks of MMF, tie wires replaced if union is not satisfactory. To follow patients and monitoring for late complications, patients seen every 2 weeks after immobilization for the first 2 months then every month for at least 6 months.

RESULTS
In this study 26 of the injured patients were males 81.8% (table 1). Patients with age group 20-29 years are mainly subjected to missile injuries as shown in table 2. Mandibular body was the commonest site for comminuted fractures 50% (table 3). Transient and permanent complications showed high rate 53.1% and less than half of patients 40.6% required further reconstructive surgery as shown in tables 5 and 6. There was statistically significance at probability level < 0.05.

Table 1: Gender distribution.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>26</td>
<td>81.8</td>
</tr>
<tr>
<td>Female</td>
<td>6</td>
<td>18.8</td>
</tr>
</tbody>
</table>

Table 2: Age distribution.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-19</td>
<td>2</td>
<td>6.2</td>
</tr>
<tr>
<td>20-29</td>
<td>18</td>
<td>56.2</td>
</tr>
<tr>
<td>30-39</td>
<td>8</td>
<td>25</td>
</tr>
<tr>
<td>40-49</td>
<td>4</td>
<td>12.5</td>
</tr>
</tbody>
</table>

Table 3: Number of patients and fracture site.

<table>
<thead>
<tr>
<th>Site of fracture</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>body region angle</td>
<td>16</td>
</tr>
<tr>
<td>symphysis-parasymphysis</td>
<td>7</td>
</tr>
<tr>
<td>Ramus</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 4: Imaging studies.

<table>
<thead>
<tr>
<th>Imaging study</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posteroanterior</td>
<td>32</td>
<td>100</td>
</tr>
<tr>
<td>True lateral</td>
<td>32</td>
<td>100</td>
</tr>
<tr>
<td>OPG</td>
<td>20</td>
<td>62.5</td>
</tr>
<tr>
<td>Oblique lateral</td>
<td>5</td>
<td>15.6</td>
</tr>
<tr>
<td>Occipitomental</td>
<td>4</td>
<td>12.5</td>
</tr>
<tr>
<td>Occlusal</td>
<td>2</td>
<td>6.2</td>
</tr>
<tr>
<td>CT scan</td>
<td>3</td>
<td>9.3</td>
</tr>
</tbody>
</table>
Table 5: 37 complications in 17 patients with 53.1% complication rate.

<table>
<thead>
<tr>
<th>complication</th>
<th>number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wound infection</td>
<td>6</td>
</tr>
<tr>
<td>Significant bone loss</td>
<td>3</td>
</tr>
<tr>
<td>Neurological complication</td>
<td>12</td>
</tr>
<tr>
<td>Occlusal abnormalities</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 6: Patients that required further surgery.

<table>
<thead>
<tr>
<th>Site of fracture</th>
<th>Number of patients</th>
<th>%</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body</td>
<td>7</td>
<td>53.8</td>
<td>21.8</td>
</tr>
<tr>
<td>Angle</td>
<td>2</td>
<td>15.3</td>
<td>6.2</td>
</tr>
<tr>
<td>Sympysis-parasymphysis</td>
<td>4</td>
<td>30.7</td>
<td>12.5</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>100</td>
<td>40.6</td>
</tr>
</tbody>
</table>

DISCUSSION

The majority of missile injuries to the lower face region in this study occurred in the age groups 20-29 years 56.2% this finding concur with most reported series of facial missile injuries of Hollier (20), Motamedi (21) and Kummoona (22) which show that these injuries were most common in young adult males. The frequency of missile injuries among males 81.2% more far greatly than that for females 18.8%, the reason may be due to the higher activity and males were mostly involved in the outdoor activities in this Arab Society, they were the most target victims for attacks as a result of deterioration in the circumstances at the present time in our country due to occupation.

Mandibular body was the most common fracture site 50%, Newlands et al (23) reported the distribution of a total 67 mandibular fractures due to gunshot injuries, in that the body fractures were the most common 38.8 followed by the angle and then the anterior region, while Akhlaghi & Aframian- Farnad (24) found during the Iraq-Iran war that the most common injury site to the mandible was a defect in the anterior region. The mandibular body region comprises a large surface area while condyles and coronoid regions were subjected to fewer fractures due to its smaller surface area. In addition, most of cases were injured from the lateral side which tend to involve the body region rather than other sites, this differ from the battlefield face to face front line conflict in the anterior region of the mandible was the most commonly involved.

Missile injuries ranges from gross comminution of the mandible to simple fracture, M.Shaker (25) reported 76.9% in 60 patients of mandibular fractures were comminuted, the high incidence of fracture comminution due to missile injury related to the high energy dissipated from the missile on impact the compact mandibular bone leading to its fragmentation.

In this study, the panoramic radiograph was the best informative view in diagnosing mandibular fractures in only single radiograph, however it was used in only 20 patients 62.5% according to the availability in our center, 2 plain radiographs at right angle to each other (poseroanterior and true lateral views) were used for all patients for localization of retained bullets or sharpnells and for diagnosis of fractures.

A stereolithographic model as illustrated in Figure 1 in which a three-dimensional reconstruction of mandibular bone was made from CT scan images in 2 patients to determine the amount of bone loss, these were handheld life-size model of the facial bones made of a plastic resin which were useful in planning treatment and allow our surgeons to estimate the extent of damage to the maxillofacial skeleton and determine the size of mandibular bony defect for subsequent reconstructive procedure with bone graft. CT scan was recommended for only 3 patients due to its cost, time consuming and hospital facilities that limits its use.

Numerous series like Chen et al (26), Deveci et al (27) and Hollier et al (20) advocated early aggressive intervention for one stage reconstruction and open treatment of all involved structures. However several series favor a more conservative approach likes Demetriades et al (28), Perry & Phillips (29) who advocating non-operative management of these injuries due to high incidence of infection. Haug & Assael (30) said that a simpler method should be chosen whenever it is as effective as a more invasive one. We preferred the conservative approach in treatment and reserve the complicated reconstrution for later, the traditional and most proven approach was to use the simplest, inexpensive and most direct feasible method for fracture reduction, fixation and immobilization usually with the use of maxillomandibular arch bar fixation. In severely comminuted and contaminated war injuries the blood supply may be compromised, the additional trauma by open procedures may lead to devitalization of bone fragments (sequestration) and loss of bony substance (due to necessary stripping of...
mucoperiosteal attachment and its blood supply to the osseous fragments in open procedures).

Closed reduction and indirect skeletal fixation was used as the modality of choice in this study for all cases. Arch bars (Erich pattern) applied due to their availability, ease of application and shorter operation time. Displaced fractures were treated initially with interarch elastics applied to the arch bars (Figure 2), and it was noted that fracture displacement will be reduced within short time (5 minutes) provided that it was applied in the right way (no crossing).

Complications were common in these series with 17 out of 32 patients experiencing one or more complications 53.1%, this high complication rate was acceptable since many of complications were transient. There is a relatively high rate of wound infection in this study 16.2% compared with Zaytoun et al (31) 12% and Akhlaghi & Aframian-Farnad (24) 11.4%, this high rate may be explained that many of missile injuries could not be treated in a strict aseptic techniques which were not always possible in the event of mass casualties due to hospital facilities.

The incidence of significant bone loss was 35.13% in 13 patients who subsequently require the use of autogenous bone graft. Chambers & Scully (32) reported a less incidence of bone loss from the mandible 27.5% in 16 out of 58 patients with missile injuries. The loss is related to the high energy imparted at impact and to the effect of shock wave and temporary cavitation produced by high velocity missile resulting in extensive tissue damage.

Fracture of the mandible within the course of inferior alveolar nerve frequently results in nerve injury and altered neurosensory function; this may be due to direct injury or secondary injury due to the line of fracture or missile path or a secondary insult due to manipulation and temporary reduction of the fracture. The predominant sign was paraesthesia in the lower lip and chin regions in addition to the gingiva and teeth which was found in 32.4%. The degree of nerve injury determine whether the impairment of sensory function being transient or permanent.

Occlusal abnormalities reported in 6 patients 16.2% in which minor or gross abnormalities were seen, this may be due to severe bone destruction under the influence of muscle pull or simultaneous severe bone destruction to upper jaw and teeth. Minor discrepancies may be acceptable or can be corrected by selective grinding of teeth, while gross abnormalities require further treatment (Figure 5).

Figure 1: 3-d reconstruction life-size model of facial bones made from CT scan image, amount of bone loss can be accurately estimated.

Figure 2: (A) Postoperative view showing comminuted fracture of left mandibular angle. (B) Closed reduction utilizing arch bars & elastic traction. (C) Frontal view 3 months after injury. (D-E) Postoperative occlusal relationship, note the nice occlusion result.
Figure 3:
(A) Transverse perforating missile injury.
(B) Postoperative OPG showing bilateral fractures (comminuted right body) treated by closed reduction using arch bars.
(C) Axial CT scan demonstrating bilateral fractures (arrowed).
(D) Frontal view showing reasonable occlusal relationship.
(E) Acceptable mouth opening without limitation at the longest follow up.
(F) Outlet side healed by secondary intention, note the bony prominence at the lower border.

Figure 4:
(A) Bullet injury causing bilateral multiple comminuted fractures with massive tongue injury decussating urgent tracheostomy & nasogastric tube feeding.
(B) Lateral radiograph demonstrating severe downward & posterior displacement of the anterior mandible.
(C) Postoperative panoramic view demonstrating the acceptable lower border.

REFERENCES