RESEARCH ARTICLES

RECONSTRUCTION OF GUNSHOT WOUNDS OF THE FACE

Mustafa DEVECİ, M.D., Mustafa SENGEZER*, M.D., Naki SELMANPAKOĞLU*, M.D.

Diyarbakır Military Hospital, Plastic and Reconstructive Surgery Clinic, Diyarbakır, Turkey
GATA, Department of Plastic and Reconstructive Surgery*, Ankara, Turkey
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SUMMARY :

Purpose : *The advent of maxillofacial surgical techniques; extended open reduction, rigid fixation with various plates and screws, and the replacement of severely damaged or missing bone with immediate bone grafting facilitate the management of severe gunshot wounds of face. The purpose of this paper is to review the results with early definitive treatment in patients with maxillofacial gunshot wounds.* ***Methods :*** *Between November 1994 - October 1996 , 31 patients were operated on for gunshot wound of the face. 8 patients had only mandibular injuries whereas 23 patients had zygomatic and / or maxillary injuries. Although two of them had no bone defect but comminuted fractures at several sites of the mandible, 4 patients with mandibular injuries were treated by use of reconstruction plates. Four patients with mandibular injuries were treated by mini - compression plates and mini - plates or intermaxillary fixation. Fifteen primary bone grafts were used in 12 patients. Seven midfacial buttresses in seven patients, and four orbital floors were reconstructed in four patients by rib grafts. In two patients with gunshot wound of mandible, the defects were reconstructed by bone grafts secondarily.* ***Results :*** *The patients' postoperative appearances were acceptable to both the patient and surgeon. None of the patients with orbital and / or zygomatic injury complained from diplopia or enophtalmus. Two patients with mandibular injury developed minimal malocclusion which required no revisional surgery.* ***Conclusion :*** *In conclusion, the goal of the management of gunshot wounds of the face is to achieve better aesthetic and functional results. Therefore, the principles of management must include extended exposure, rigid fixation by plates and screws, and primary bone grafting (except mandible) if needed in the early postoperative period.*

Key Words : *Facial Injuries , Gunshot Wounds , Fracture Fixation , Facial Bone Injury , Facial Bone Surgery.*

INTRODUCTION

The energy of a projectile or a shrapnel is proportional to its mass and velocity. Because the kinetic energy determines, among other factors, the soft tissue and bone damage, it is useful to characterize gunshot injuries as low, intermediate and high velocity. High velocity injuries are generally not seen in civilian practice (1- 3). The missile velocity of a handgun is 91.4 meters per second whereas the missile velocity of a military rifle is 760 meters per second. Military rifles are associated with high velocity injuries , with bullets of larger mass travelling at speeds more than 760 meters per second. The nature of the extent of the wound is determined by the velocity of missile, the distance of the victim from the muzzle of the rifle, the pattern of the missile, the number of missiles that hit the patient, the size of missiles, and deflection of the missile (3).

Historically, gunshot wounds of the face were managed by debridement and closure of soft tissue. The bone was reconstructed secondarily (2- 6). If the soft tissue is left to heal, contract, and collapse, later attempts for bony reconstruction will rarely restore the original soft tissue position, contour and suppleness (1- 4, 7). Traditional management of these wounds dictates initial debridement and closure of the soft tissues combined with external fixation of the remaining maxillary and mandibular bone segments (1).

The first priority is the airway in the management of gunshot wounds of the face. Life - threatening haemorrhage is unusual. Ophthalmologic and neurosurgical consultations are appropriate and ideally obtained in the emergency room. The CT scan is the radiologic examination of choice, although conventional techniques may be helpful (1).

The principles of immediate wound care, with conservative debridement of bone and soft tissue, have been previously reported by several authors (1, 8). In severe injuries with extensive bone and soft tissue injury or loss, the immediate debridement and temporary soft tissue repair to cover exposed bone is followed by further debridement as necessary. Within 7 to 10 days, delayed primary definitive reconstruction and replacement of missing midfacial bone and soft tissue are performed (1). So far, few authors have supported the concept of primary bone reconstruction and definitive soft tissue repair in the management of gunshot wounds of the maxillofacial region (1, 7, 8). The surgical approach, of course, depends on the extent of injury. Manson reported that four components of injury of gunshot wounds that need to be assessed (3). These are soft tissue injury, bone injury, soft tissue loss, and bone loss. Mladick et al. have pointed out the importance of immediate flap reconstruction for massive gunshot wound of face in 1970 (8).

It was shown that axial compression of mandibular fractures produced healing with primary lamellar bone, rather than with the typical callus formation (9). Experience of orthopaedic, maxillofacial, and subsequently craniofacial surgeons have shown that rigid fixation of bone segments decreases the incidence of infection; even if the metal plate and bone become exposed, healing will still occur in the bone, provided the bone margins are rigidly fixed together. In the repair of all facial fractures that involve the upper or lower dental arch, it is essential to re-establish the correct occlusion prior the application of plate or screw fixation, as failure to do this will maintain stabilised segments in an incorrect position, and it is impossible to move these stabilised segments secondarily by any orthodontic means. It is reported that bone grafting at the time of original repair always gives a superior result as compared with secondary bone grafting. Bone grafts, especially in the midface and nasal area, will maintain soft tissue expansion and projection even if the segments become exposed. Adequate fixation of bone grafts is essential, as inadequate fixation predisposes to infection or resorption (1-3).

PATIENTS AND METHODS

Between November 1994 - October 1996, 31 patients with maxillofacial gunshot wound were treated at Diyarbakır Army Hospital. All patients were male and their ages ranged from 20 to 50 (mean 22.9). Twentysix patients were injured by high velocity military rifles and five were injured by low velocity shrapnels. None of the injuries was caused by close range shotgun blasts. All wounds resulted from assaults or accidents, and none of them was suicide attempt. Patients with maxilofacial gunshot wounds were admitted to the hospital at days 1 - 5 (mean 1.7) after injury. All patients underwent operation at days 1 - 7 (mean 2.9) after admission. Eight patients had only mandibular injuries, 23 patients had zygomatic and maxillary injuries. Although two of them had no bone defect but comminuted fractures at several sites of the mandible, four patients with mandibular injuries were treated by use of reconstruction plates. Four patients with mandibular injuries were treated by mini - compression plates and mini - plates or intermaxillary fixation.

Fifteen primary bone grafts were used in 12 patients. Three buttresses and one orbital floor reconstruction were required in one patient , and single buttress or orbital floor reconstruction by use of bone graft was required in 11 patients. Seven midfacial buttresses were reconstructed by rib grafts in seven patients, and four orbital floors were reconstructed in four patients. All grafts were harvested from rib and used in split form. In order to provide correct occlusal relation, intermaxillary fixation was performed prior to the operation in patients with mandibular and / or maxillary fractures.

Patients with maxillary or zygomatic injuries were treated with open reduction and rigid fixation by mini - plates and reconstruction by use of rib grafts if needed. Bone grafts for reconstruction of zygomatic and maxillary buttresses were fixed by lag screws or mini - plates. In two patients with gunshot wound of mandible, reconstruction plate was used for bridging the edges of the defect and soft tissue repair was performed at first session. The patients underwent operation and reconstruction by secondary bone grafting was performed at four months postoperatively. The bone graft was harvested from iliac spine. Patients with craniofacial gunshot wound underwent operation and cranioplasty was performed by using metylmetacrylate at six months postoperatively. The average postoperative follow-up of the patients was 9 months. The summary of the patients are presented in the Table - 1.

CASE 1

A 20-year-old male patient was admitted to the hospital at posttraumatic 6 h. Physical examination revealed entrance wound at right preauricular region and exit wound at left nasolabial region with 4 cm. traumatic laceration (Fig. 1a, b). X - ray examination revealed fractures at bilateral maxillary buttresses, right zygomatic buttress and right subcondylar region. Palatal structures were found to be intact. The patient underwent operation at posttraumatic 2 days. Fractures sites were exposed by coronal, and upper gingivobuccal and bilateral subciliary approaches. Prior to the operation, in order to achieve correct occlusal relation an acrylic plate was prepared. Three midfacial buttresses and right orbital floor were reconstructed by use of split rib grafts. The fractures at infraorbital rims and nasoethmoidofrontal region were reduced and fixed by mini - plates (Fig. 1c). Right medial canthal ligament was repaired. Exposure of bone graft and mini - plate at right gingivobuccal sulcus were observed at early postoperative period. The defect was covered with moist dressings and

Fig - 1a : Anterior views of the victim after the injury.

Fig - 1b : Lateral views of the victim after the injury.

CASE	AGE	SEX	ADMISSION TIME	ETIOLOGY	TYPE	LOCATION	TIMING	OPERATION	COMPLICATION
G.A.	21	MALE	1DAY	ASSAULT	HIGH	MANDIBLE + MAXILLA	1DAY	ORIF	NO
M.Ç.	20	MALE	3 DAYS	ASSAULT	HIGH	MANDIBLE + LEFT MAXILLA	4 DAYS	RECONSTRUCTION PLATE + SEC.ONDARY BONE GRAFTING	NO
R.Y.	24	MALE	1 DAY	ASSAULT	HIGH	MANDIBLE	4 D AYS	ORIF	NO
S..A.	21	MALE	5 DAYS	ASSAULT	LOW	LEFT ZYGOMA	7 DAYS	ORIF	NO
K.D.	26	MALE	2 DAYS	ASSAULT	HIGH	LEFT ZYGOMA	4 DAYS	ORIF + PRIMARY BOONE GRAFTING	NO
I.A.	21	MALE	1 DAY	ASSAULT	HIGH	MANDIBLE + RIGHT ZYGOMA	1 DAY	ORIF + RECONSTRUCTION PLATE + SECONDARY BONE GRAFTING	NO
E.Y.	22	MALE	1 DAY	ASSAULT	HIGH	CRANIOFACIAL	1 DAY	ORIF + SEC.ONDARY CRANIOPLASTY + PALATE REPAIR	NO
M.E.	23	MALE	1 DAY	ASSAULT	HIGH	CRAIOFACIAL	1 DAY	ORIF + SECONDARY CRANIOPLASTY	NO
A.K.	21	MALE	2 DAYS	ASSAULT	LOW	MANDIBLE + LEFT ZYGOMA	4 DAYS	ORIF	NO
K.Y.	21	MALE	1 DAY	ASSAULT	HIGH	MANDIBLE	3 DAYS	ORIF	MINIMALLY MALOCCLUSION
A.Y.	21	MALE	3 DAYS	ACCIDENT	HIGH	RIGHT ZYGOMA	4 DAYS	ORIF + PRIMARY BONE GRAFTING	PERSISTANT EDEMA
A.A.	24	MALE	1 DAY	ASSAULT	HIGH	BIL. ZYGOMA	3 DAYS	ORIF + PRIMARY BONE GRAFTING	NO
N.D.	21	MALE	1 DAY	ACCIDENT	LOW	LEFT ZYGOMA + NASAL BONE	3 DAYS	ORIF + PRIMARY BONE GRAFTING	NO
M.D.	22	MALE	1 DAY	ASSAULT	HIGH	MANDIBLE	2 DAYS	ORIF (REC. PLATE)	NO
O.G.	21	MALE	1 DAY	ACCIDENT	HIGH	MANDIBLE	2 DAYS	ORIF	NO
Y.T.	24	MALE	1 DAY	ASSAULT	HIGH	MANDIBLE	2 DAYS	ORIF	CROSS-BITE
A..A.	21	MALE	4 DAYS	ASSAULT	HIGH	LEFT ZYGOMA + MAXILLA	4 DAYS	ORIF + PRIMARY BONE GRAFTING	NO
S.A.	26	MALE	3 DAYS	ASSAULT	HIGH	LEFT ZYGOMA	4 DAYS	ORIF + PRIMARY BONE GRAFTING	NO
R.P.	32	MALE	1 DAY	ASSAULT	HIGH	MANDIBLE + LEFT ZYGOMA	3 DAYS	ORIF + PRIMARY BONE GRAFTING	NO
S.T.	50	MALE	1 DAY	ASSAULT	HIGH	MANDIBLE	2 DAYS	ORIF REC. PLATE)	NO
T.E.	21	MALE	1 DAY	ACCIDENT	HIGH	BIL. ZYGOMA + BIL. MAXILLA	2 DAYS	ORIF + PRIMARY BONE GRAFTING	PLATE EXTRUSION
E.Y.	22	MALE	3 DAYS	ASSAULT	LOW	MANDIBLE	4 DAYS	ORIF	NO
N.D.	23	MALE	1 DAY	ASSAULT	HIGH	MANDIBLE + RIGHT MAXILLA	2 DAYS	ORIF	NO
K.T.	21	MALE	1 DAY	ASSAULT	HIGH	MANDIBLE	2 DAYS	ORIF	NO
H.Y.	24	MALE	3 DAYS	ACCIDENT	HIGH	LEFT ZYGOMA	4 DAYS	ORIF + PRIMARY BONE GRAFTING	NO
M.K.	22	MALE	2 DAYS	ASSAULT	HIGH	MANDIBLE	3 DAYS	ORIF	NO
Y.S.	24	MALE	2 DAYS	ASSAULT	HIGIH	MANDIBLE	3 DAYS	ORIF	NO
B.E.	26	MALE	1 DAY	ASSAULT	HIGH	RIGHT MAXILLA+ ZYGOMA	3 DAYS	ORIF + PRIMARY BONE GRAFTING	NO
E.D.	27	MALE	1 DAY	ASSAULT	LOW	LEFT ZYGOMA	2 D AYS	ORIF	NO
I.R.	21	MALE	3 DAYS	ASSAULT	HIGH	RIGHT MAXILLA + ZYGOMA	4 DAYS	ORIF + PRIMARY BONE GRAFTING	NO
E.Y.	21	MALE	2 DAYS	ASSAULT	HIGH	LEFT ZYGOMA	3 DAYS	ORIF + PRIMARY BONE GRAFTING	NO

ORIF : Open reduction and internal fixation
REC. PLATE : Reconstruction plate

Table 1 : The summary of the patients.

irrigated frequently with saline solution. Secondary healing was achieved eventually. Optimal occlusion was achieved and aesthetic appearance was found to be satisfactory at 6-month-follow up (Fig. 1d, e).

CASE 2

A 21-year-old male patient was admitted to the emergency service at posttraumatic 4 h. Physical examination revealed entrance wound at suubmental and exit wound at frontal regions (Fig. 2a). Airway was achieved by tracheostomy. X-ray examination revealed fractures at mandible, maxilla, nasal bone and frontal bone. The patient underwent operation and repair of duramater, and open reduction and rigid fixation of fractures were achieved by mini plates and screws. Soft tissue repair was performed primarily (Fig. 2b). Six months following the frst operation , the patient underwent operation again and closure of palatal defect by local flaps and cranioplasty by metylmetacrylate were performed. The final appearance and functional results were found to be satisfactory to both patient and the surgeon (Fig. 2c, d).

CASE 3

A 21-year-old male patient was admitted to our hospital at posttraumatic 3 days. Physical examination revealed entrance and exit wounds at right nasolabial and left zygomatic area respectively (Fig. 3a). X-ray examination revealed comminuted fracture at left zygoma. The patient underwent operation and rigid fixation of left zygoma and reconstruction of orbital floor with split rib graft was performed. No complication occurred and the patient did not complain of diplopia and enoftalmus. Final appearance was

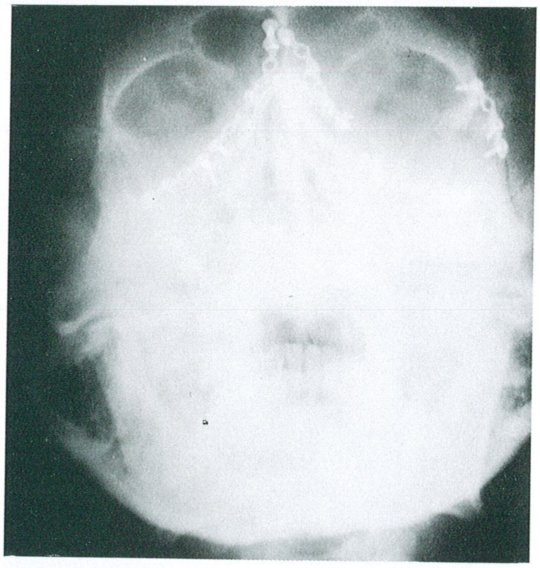

Fig - 1c : X-ray of the same patient after open reduction and rigid fixation.

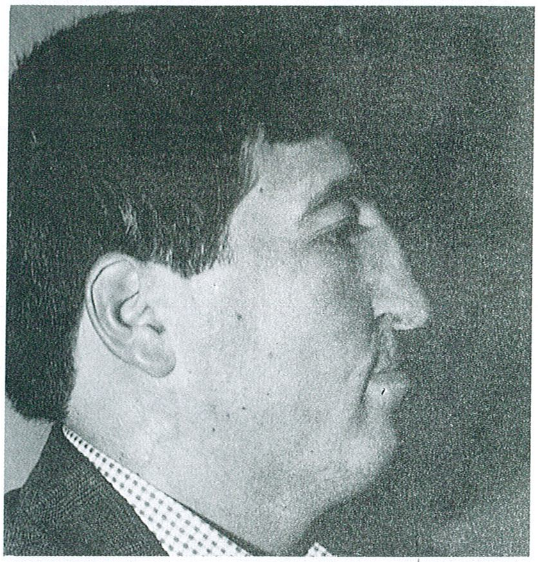

Fig - 1e : Lateral views of the patient, 6 months postoperatively.

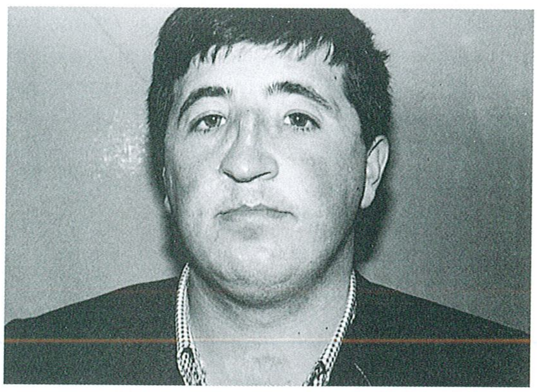

Fig - 1d : Anterior views of the patient, 6 months postoperatively.

Fig - 2a : Appearance of the victim immediately after the injury.

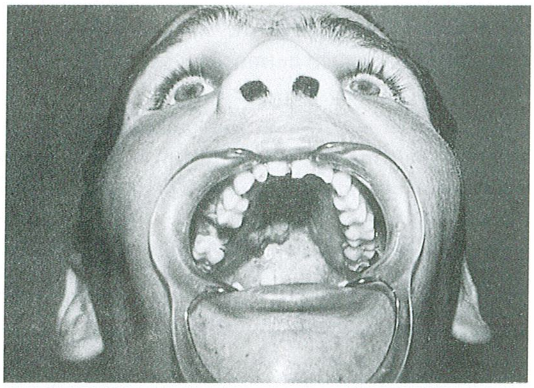

Fig - 2b : Appearance of the patient at 6 months postoperatively (Please note the palatal defect).

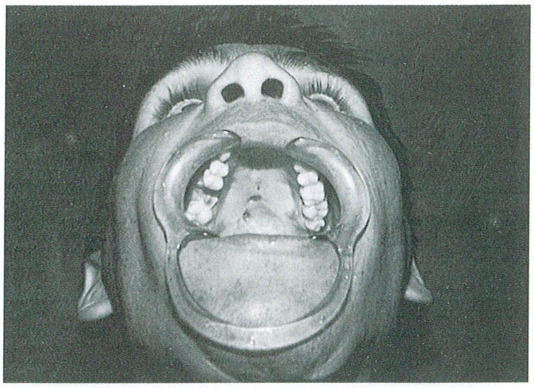

Fig - 2d : Appearances of the patient at one year postoperatively, after repair of the palate and cranioplasty by using metylmetacrylate.

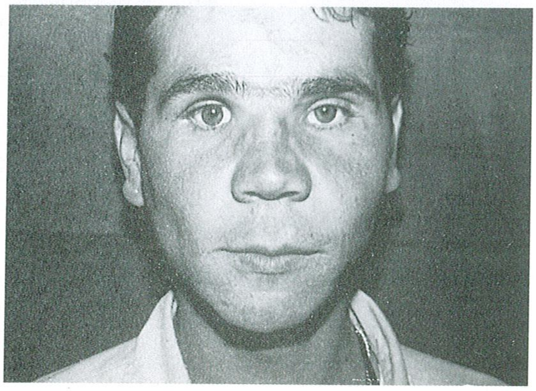

Fig - 2c : Appearances of the patient at one year postoperatively, after repair of the palate and cranioplasty by using metylmetacrylate.

found to be satisfactory (Fig. 3b, c).

CASE 4

A 20-year-old male patient with gunshot wound of his mandible was admitted to the hospital at the day of injury. Physical examination revealed entrance wound at left cervical area and exit wound at symphyseal region. X-ray examination revealed bone defect and comminuted fracture at symphyseal area. The patient underwent operation and reconstruction of the mandible with a reconstruction plate and soft tissue repair following debridement of bone fragments were performed

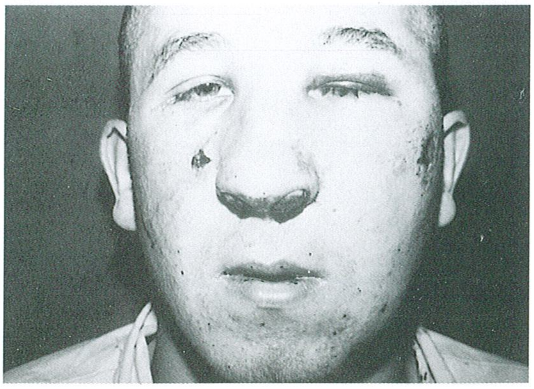

Fig - 3a : Appearance of the victim at 3 days after injury.

(Fig. 4a, b). Prior to the operation interdental fixation was achieved. The patient was returned to the operation and the reconstruction of mandible with bone graft from iliac spine was performed at four months postoperatively (Fig. 4c, d). Occlusion was found to be satisfactory at 3 months postoperatively. No complication relating to the donor site has been noted (Fig. 4e).

RESULTS

No serious infections causing extrusion or necessitating removal of any bone graft have occurred. In only one patient the bone graft and mini - plate became exposed in the early

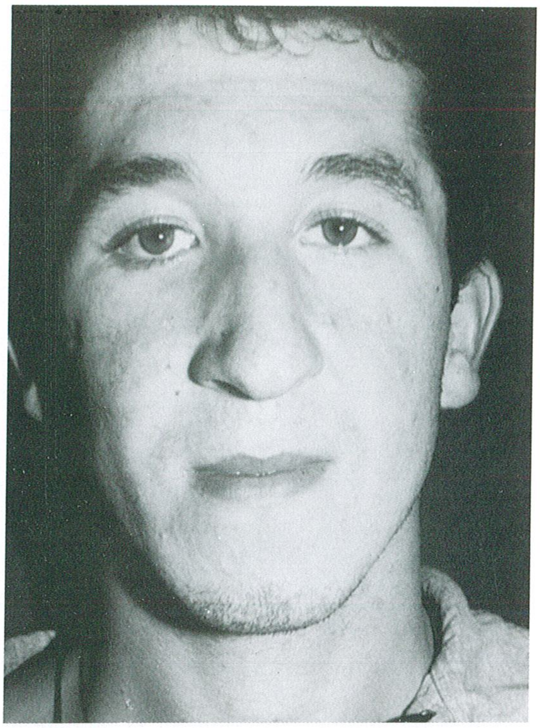

Fig - 3b : Appearances of the patient at 6 months postoperatively (Please note malar depression has been restored).

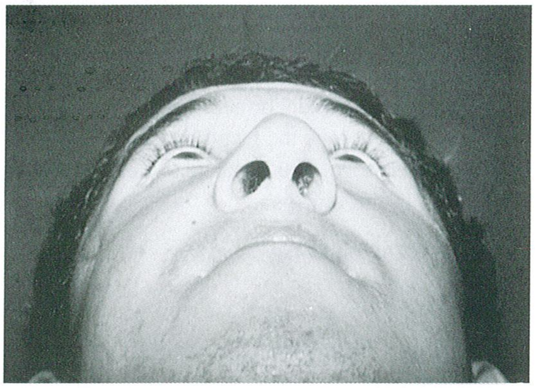

Fig - 3c : Appearances of the patient, 6 months postoperatively (Please note malar depression has been restored).

postoperative period due to severe mucosal injury. Bone graft and mini - plate were left in place. The defect was covered with moist dressing and irrigated frequently. Secondary soft tissue healing eventually occurred.

The patients' postoperative appearances were acceptable to both the patient and the surgeon. None of the patient with orbital and / or zygomatic injury complained diplopia and enophtalmus. In one patient persistent oedema was observed at

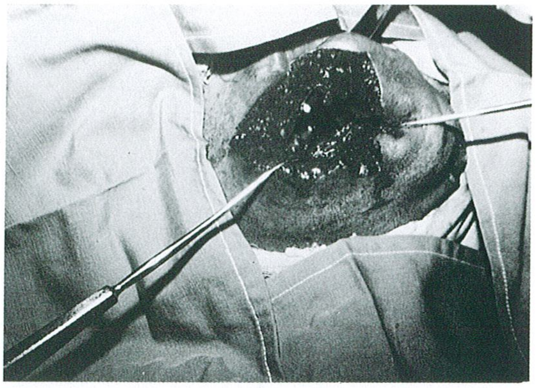

Fig - 4a : Intraoperative appearance of the bone defect at the right parasymphyseal region.

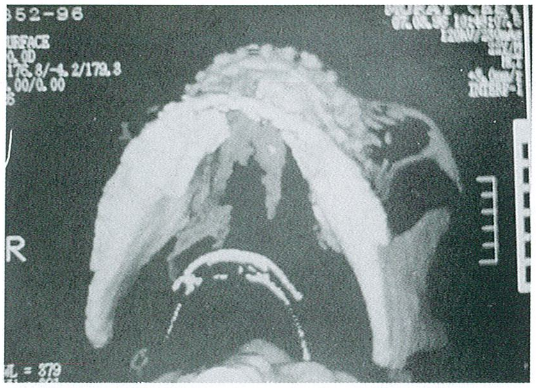

Fig - 4b : 3-dimensional computerized tomography image of the patient at 4 months postoperatively.

malar region in late postoperative period. Two patients with mandibular injury developed minimal malocclusion which required no revisional surgery.

Complications related to donor site or the bone graft itself have been minimal. No pneumothorax associated with the harvesting of rib graft has been noted.

DISCUSSION

In the management of gunshot wounds of the face, initially basic principles of life support are indicated : establishment of airway, control of bleeding, and maintanence of circulation. More often, measures such as suctioning of clots and

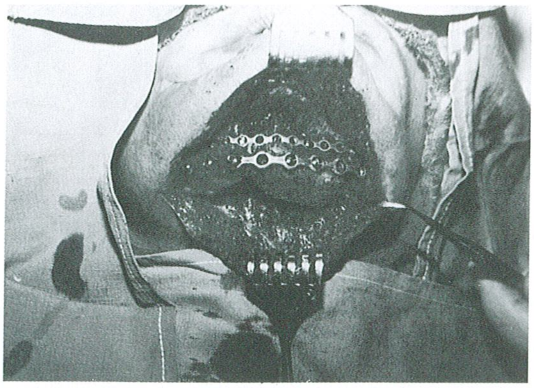

Fig - 4c : Intraoperative appearance shows reconstruction by using iliac bone graft. A mini-plate was used to achieve rigid fixation in addition to the reconstruction plate.

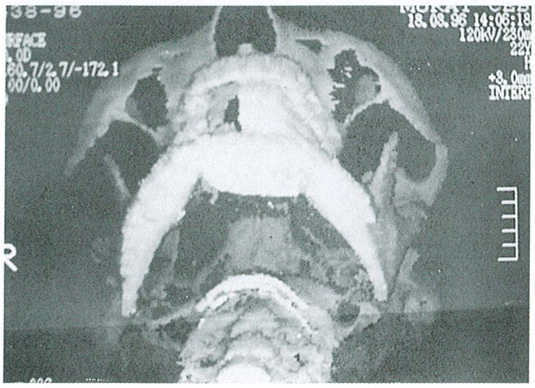

Fig - 4d : 3-dimensional computerized tomography image of the patient after secondary bone grafting shows the location of the graft.

debris, maintanence of lateral head position, traction of tongue, and possible endotracheal entubation are primarily indicated. Haemorrhage can usually be controlled with local measures (4, 9).

The brain, the neck, and the eyes require special consideration. Radiological and clinical evidence of intracranial perforation by a missile dictates neurosurgical consultation. CT, echoensephalograms, or arteriograms may be indicated in such instance.

Velocity of the missile as the missile strikes the

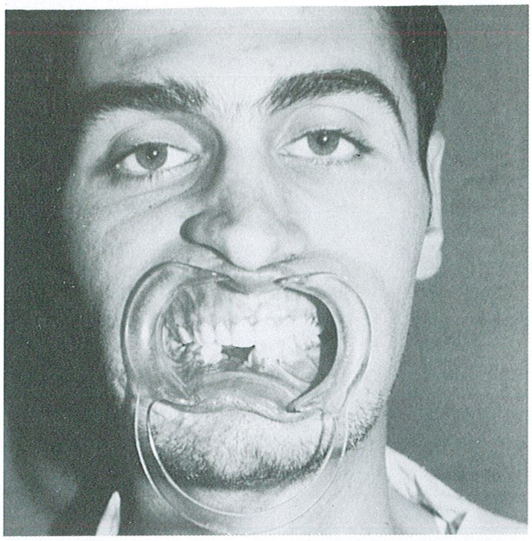

Fig - 4e : Appearance and occlusion of the patient at 6 months postoperatively.

tissue is the primary determinant in wounding capacity. The accepted formula of a missile charge at the site of injury is $E = M V 2 / 2 g$. The impact kinetic energy is equal to half of the mass of the missile and square of its velocity divided by gravitational deceleration (4, 10). Velocity is also the prime determinant in assessing tissue cavitation or the explosive effect of a missile. This blast effect is what causes broken bones, torn vessels, and tissue necrosis, despite the fact that there is no direct hit (4). Therefore, the spherical bullet causes wounding in three ways :

1. Laceration and crush
2. Shock wave
3. Temporary cavitation

In high velocity oblong-shaped missiles, the exit wound is larger than the entrance wound ; the cavitation occurs late because of thumbling of the bullet. At close range up to approximately 1 ft, a single 1-inch entrance wound with a darkened jagged rim will be produced (4). None of our patients was injured by close range shotgun blasts.

In areas of actual tissues where wound closure is not possible, the wounds are left open until flap closure can be achieved. Manson recommended the definitive closure within 24 to 48 h of the last debridement (2). Bone gaps (except those in the mandible) are reconstructed with bone grafts , and the overlying soft tissue is reconstructed by whatever means necessary.

Once midfacial and mandibular bony reconstruction is complete, soft tissue reconstruction can be completed by direct closure or local, regional , or free vascularized flaps (1). No free flap operation was needed in our patients since they were not faced with extensive soft tissue loss.

Zigomatic arch exposure is critical to facilitate adequate repair. All fractures are delineated, and stable areas of craniofacial skeleton is identified. All fractures are reduced and stabilised with mini-plates and screws. Once fracture repair is completed, areas of bone destruction are replaced with bone grafts to provide a midfacial scaffolding for soft tissue support or subsequent flap replacement. Once the orbital rim reconstruction is completed, deep orbital exposure and bone grafting, with either calvarial or rib grafts, are used to replace the missing orbital floor, facilitating reconstruction of the correct orbital volume (1). In our cases rib grafts were preferred for orbital floor reconstruction because of easiness of its harvesting and bending. Maxillary bone itself or any midfacial buttress damage must be reconstructed by split rib graft for achieving midfacial height (2, 3).

Frequently, failure to reconstruct the underlying bony skeleton will result in rapid shrinkage of soft tissue, especially in the midface, making adequate secondary bone reconstruction difficult and sometimes impossible (1). The solution to the problems of midfacial bony collapse, soft tissue shrinkage, and scarring lies in the early exposure of all fracture segments and their repair, using internal fixation techniques. Definitive repair can be delayed up to 7 days, but this increases the difficulty in obtaining adequate reduction and fixation (11). Therefore, in our patients definitive treatment was performed before 7 days post - injury. We believe that complications can be reduced by this way.

Although calvarial bone grafts are now the invariable source of bone in the management of acute facial fractures, they are difficult to bend and obtain in segments that have sufficient length. In gunshot wounds with extensive bone loss, combination of calvarial and rib or iliac grafts are usually needed. Split rib grafts can be bent to replace contagious areas of the orbital rims and walls , and long full-thickness rib grafts are ideal to bridge across the midface for maxillary replacement. All bone grafts , except in reconstruction of the deep orbit, are rigidly fixed with lag screws (1, 11) or miniplates (1, 12). We did use split rib grafts to reconstruct the midfacial buttresses. In the reconstruction of orbital floor, split rib grafts were fixed by wire fixation. Prompt re-establishment of bony skeleton prevents the collapse and contracture of overlying soft tissue. The principles of facial fracture management, including extended exposure, plate and screw fixation, and acute bone grafting, as outlined by several authors , are also applicable to gunshot wounds (1, 2, 13). Miniplates can bridge bony gaps of up to approximately 0.5 cm in most areas of the craniofacial skeleton. Thus, gaps greater than this size must be replaced with bone grafts

Injury to the mandible may result in unilateral, bilateral, segmental or comminuted fractures. Fractures with bone defects may also occur. The correct occlusion, using remaining tooth-bearing segments of the maxilla and mandible, is established with interdental wiring. Fractures with or without comminution, segmentation, or defect are repaired whenever possible with mandibular compression or reconstruction plates (1, 9). Fractures with bone gaps are bridged by reconstruction plates anchored at each end with a minimum of four screws. Primary bone grafting for mandibular defects is rarely indicated because the reconstruction plates will maintain the bone gap until soft tissue healing has occurred, allowing safe, delayed bone reconstruction. Although primary bone graft reconstruction of the midface is the cornerstone of repair and has few major complications, primary bone graft in replacement of mandibular defects has unacceptably high complication rate (1).

Primary bone grafts for traumatic mandibular defects are unpredictable and have a high incidence of significant resorption even if infection does not occur. The position of mandibular bone segments can be readily maintained by use of strong, three dimensionally bendable reconstruction plates that are rigidly fixed to the bone stump at either end (1, 9). These plates act as a spacer until soft tissue healing is complete. Definitive bone reconstruction can then be accomplished through an external approach with maintaince of the intraoral seal. In defects up to 3 to 4 cm, conventional iliac cancellous bone grafting is used. It is always essential to eventually bridge a mandibular defect with bone, since the plate alone will not maintain adequate stability against the continued forces of mastication (1). Thorne also has pointed out that far more complications arise from unnecessary delay than from premature intervention (2).

In conclusion, the goal of the management of gunshot wounds of the face is to achieve better aesthetic and functional results. Therefore, the principles of management must include extended exposure, rigid fixation by plates and screws, and primary bone grafting (except mandible) if needed in the early postoperative period.

Correspondence to : Dr.Mustafa DEVECİ
GATA
Plastik ve Rekonstrüktif Cerrahi
Anabilim Dalı
Etlik
06018 ANKARA - TÜRKİYE
Phone : 312 - 321 37 07

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