Egypt, J. Plast. Reconstr. Surg., Vol. 41, No. 2, July: 301-309, 2017

Evaluation of the Role of Three-Dimensional Miniplate Technique in Internal Fixation of Mandibular Fractures

MOHAMED EL-ESSAWY, M.D.; AHMED F. ABORADY, M.D.; HATEM EL-SAHHAR, M.D. and AHMED FATHY EL-SAYED, M.D.

The Department of Plastic Surgery, Faculty of Medicine, Cairo University

ABSTRACT

Background: Mandibular fractures are commonly encountered nowadays with the increase in magnitude of road traffic accidents together with social violence. Several methods have been used for management of this type of fractures. A relatively less popular tool is the use of 3D plating system for fixation.

Patients and Methods: A prospective study was conducted in the plastic surgery emergency unit involving twenty patients. 23 out of 32 total mandibular fractures were successfully managed with 3D plates. Patients were followed-up for 6 weeks for stability of fixation and restoration of function.

Results: One patient presented with malocclusion that was managed conservatively. Other complications like plate failure, surgical site infection or plate exposure were not recorded.

Conclusion: 3D plating system represents a useful tool for fixation of mandibular fractures. They are mechanically stable, easily applied with shorter operative time.

Key Words: *Mandible – Fracture – Fixation – 3D plates.*

INTRODUCTION

Mandibular fractures are a common presentation to the plastic surgery trauma service. They account for 36% to 59% of all maxillofacial fractures. Road traffic accidents, interpersonal assault, fall from height, and sports related injuries are the leading causes of mandibular fractures, with higher prevalence among male patients **[1]**.

The primary objective in management of mandibular fractures should include proper restoration of the function of mastication and articulation in addition to restoration of the pre-injury occlusion. This can be achieved through proper reduction and fixation of the fracture together with prevention of infection at the fracture site **[3]**.

Different methods of fixation have been used in maxillofacial surgery armamentariu: Wires, pins, staples, plates, and screws, each offering different degree of rigidity ranging from non-rigid fixation by wires, semi-rigid fixation offered by miniplates and screws, to rigid fixation by compression plates and lag screw technique **[7]**.

A breakthrough in the field was achieved when Mostafa Farmand (in 1992) developed a new miniplate system, which takes advantage of the biogeometry to provide stable fixation and he called it a "3D plating system". The 3D plating systems are based on the principle of obtaining support through geometrically stable configuration **[1]**.

PATIENTS AND METHODS

This prospective study was conducted in the emergency plastic surgery department in Kasr Al-Ainy Hospital over a six months period. Starting from February 2016 till September 2016. It included 20 patients presenting with mandibular fractures.

Inclusion criteria:

Patients above the age of 12 years suffering from mandibular fractures which is indicated for open reduction and internal fixation:

- Displaced unfavorable fractures.
- Multiple fractures.
- Associated condylar fractures.
- Associated midface fractures.
- When closed reduction (IMF) is not possible.

Exclusion criteria:

- Patients below the age of 12 years.
- Grossly comminuted fractures.
- Presence of evidence of infection.
- Severely lacerated soft tissue and risk of implant exposure is present.
- Coronoid process fractures.
- Severely atrophic edentulous mandible.

The aetiology of the trauma varied between road traffic accidents, fall from height, interpersonal assault, and sport related injury.

Table (1): Causes of mandibular fractures.

Aetiology	Number of patients	Percentage
Road traffic accident	15	75
Fall from height	2	10
Assault	2	10
Sports injury	1	5

(A) *Preoperative evaluation:*

Patients were admitted to the resuscitation room where they had their trauma surveys completed. After completing their trauma surveys and stabilization of their conditions patients were transferred to the plastic emergency department for proper evaluation and preparation for their surgery.

After transfer to the plastic surgery unit, all patients received chemoprophylaxis in the form of third generation cephalosporin (Ceftriaxone) 1gm IV twice daily and Clindamycin 600mg IV twice daily. Oral feeding was restricted to only clear fluids followed by Chlorhexidine 0.125% mouthwash. In case of patients with restricted jaw mobility and suffering from painful oral intake, IV fluids were ordered to fulfill their daily requirements. Pain control was achieved by NSAIDs and parenteral paracetamol. Patients were also instructed to lie in bed with head elevation 45 degrees to reduce the facial edema.

Laboratory workup:

All patients had blood samples withdrawn on admission as part of their preoperative preparation:

- Complete blood picture.
- Coagulation profile (PT, PC, INR, PTT).
- Liver function tests and Renal function tests.
- Fasting blood glucos.

Imaging:

After stabilization of the vital signs and stabilization of the cervical spine in the emergency room, patients were sent for CT scanning of the facial bones (axial and coronal cuts, with 3D reconstruction if feasible). Plain radiographic series was not done routinely, except for certain situations in the resuscitation room where they were completing their secondary surveys to screen for the presence of mandibular fractures. Patients were sent in the following day of admission for panoramic radiographs.

Consent:

After the imaging results were brought in, confirmation of the presence of mandibular fracture, and analysis of the fracture type and nature was done. Patients with the attendance of a first degree relative received an explanation of the nature of the condition and the treatment options available. A written consent clarifying their condition was taken and kept in their hospital file. Data in the consent included:

- Diagnosis of the condition.
- Nature of the operation to be undergone.
- Risks of anesthesia.
- Expected outcomes.
- Possible complications: (Malocclusion, Implant infection, Wound dehiscence, implant exposure,..etc.).

Timing of surgery:

In our study all patients had their surgeries done within 3 to 5 days.

(B) *Operative procedure:*

Anesthesia:

All procedures in the study were done under general anesthesia. Nasal endotracheal intubation with pack insertion was performed to facilitate proper assessment of the patient's occlusion.

Position:

Patients were placed in supine position with the head fitting in a suitable sized head rest, with the neck slightly extended.

Oral cavity preparation:

Anti-septic Chlorhexidine 0.125% mouth wash was used to clean the oral cavity with a toothbrush rinsing the teeth before draping. Then after skin sterilization and draping, the same procedure was done again but with Betadine 10% and a small gauze held with a clamp.

Maxillo-mandibular fixation (MMF):

After preparation of the oral cavity, assessment of the patient occlusion and application maxillo-mandibular fixation was done to maintain the occlusion during the procedure. In this study the two used methods for MMF were Erich arch bars and Ivy loops depending on the nature of the fracture. For combined fractures or associated subcondylar fractures that were treated conservatively Erich arch bars were used. In cases where there is a single fracture, four Ivy eyelet loops were sufficient to guide and maintain the occlusion throughout the procedure.

Incision:

Preparation of a 50ml solution containing 40ml adrenalized saline with the concentration 1:200,000 and 10ml of Lidocaine 2% followed by its infiltration prior to incision to minimize the bleeding and acting as a pre-emptive analgesia.

In all cases an intra-oral mandibular vestibular approach was used to gain access for the fracture site and its fixation. A curvilinear incision was done through the mucosa 10mm-15mm from the muco-gingival junction extending from canine to canine in anterior fractures, and from midline to fracture site in body fractures. Then the mentalis muscle is incised in an oblique fashion leaving an ample amount of muscle attached to the mandible facilitating its subsequent closure. Subperiosteal dissection of the mentalis muscle then proceeds till the fracture site. If the fracture is posterior to the canine teeth, then the mental nerve was encountered, care was taken not to injure the nerve and controlled dissection of the nerve was done releasing it from the surrounding periosteum. In angle fractures same steps were followed but the incision was placed opposite to the first molar about 3mm from the muco-gingival junction and extends behind the third molar on the anterior border of the ramus.

Handling of fractured segments:

When access to the fracture site is gained, the first step was to disimpact the fractured segments and remove the fracture hematoma allowing for further proper reduction and clearing the site for adequate compression. Sometimes when Erich arch bars were used to guide the occlusion they didn't allow proper disimpaction, splitting the arch bar opposite to the fractured site was done allowing for free mobility of fractured segments. Afterwards the fractured hematoma was removed with a suction catheter and any intervening soft tissue in the fracture site was released.

After freeing of the fracture segments was done, the teeth were put in occlusion once again assisting in the anatomic reduction of the fractured segments. Then the fractured segments were held together with the aid of bone holding forceps when feasible, it prevented further displacement while applying the fixation method. It was applicable in anterior fractures, angle fractures and lamellar fractures to hold the with a bone forceps. Body fractures extending beyond the mental foramen till the angle region, it was technically difficult to apply the forceps and it may even cause slight displacement when applying it. Now the fracture is properly reduced and held into place and ready for fixation.

Three dimentional plating technique (3D miniplates):

After stabilization of the fractured segments, the 3 dimensional plate was introduced. Fixation of the 3D plate was done with 2.0mm monocortical screws at the superior bar and bicortical screws at the inferior bar in such a way that the horizontal bar is perpendicular to the fracture line and the vertical bar is parallel to the fracture line. In the symphysis and parasymphysis regions, the upper bar was placed in the subapical position. Body fractures were treated by placing the superior bar below the roots and the inferior bar below the mental nerve. At the angle a curved plate was used so the vertical crossbars were aligned perpendicular to the external oblique ridge.

Wound closure:

Wound closure was done in two layers one simple deep inverted layer for the mentalis muscle the other is continuous closing the mucosa, using absorbable polyglcolic acid 3/0 sutures.

Maxillo-mandibular fixation (MMF):

All maxillomandibular fixation was released prior completion of the procedures. Erich arch bars and Ivy eyelets loops used to guide the occlusion during the operation were left in place but without putting the patient in occlusion so that if there is any bite disturbances during the postoperative period they can assist in putting the patient in occlusion once again. Only 4 cases had the MMF left in the postoperative period.

Postoperative care:

Patients were then transferred after their recovery from the anesthesia back to the ward where they continued on their same antimicrobial regimen, instructed to lie in bed with head elevation and mouth wash was scheduled every 6 hours. Oral intake was restricted for the first 12 hours, during this period IV fluid replacement was ordered. Then clear fluids were allowed followed by mouthwash.

The next day patients were sent for postoperative imaging. Postoperative imaging consisted of panoramic view radiograph (Panorex) and CT scan for the facial bones including axial and coronal cuts, with 3D reconstruction.

Discharge:

All patients were discharged 24 hours after the operation. They were prescribed oral antimicrobial regimen and pain killers in addition to mouthwash. They were instructed to follow a soft diet and avoid excessive chewing and loading on their jaws. Post-

operative visits were scheduled 1,2,4, and 6 weeks postoperatively.

Postoperative visits:

After one week; patients were assessed for any wound complications, excessive edema, malocclusion, and any complaints or special remarks were taken into consideration. After 2 weeks patients were assessed for final wound appearance and malocclusion. In the fourth week visit patients were assessed for malocclusion and evidence of return of neurosensory deficit of the inferior alveolar nerve if it was present. In the sixth week visit patients were assessed for malocclusion, and a final panoramic view radiograph was done and compared with the immediate postoperative one. If any Erich arch bars or Ivy eyelets loops were left in the postoperative period they were removed on the sixth week visit under local anaesthesia.

RESULTS

In this study the total number of cases was 20 cases who suffered from mandibular fractures, and they all had undergone open reduction and internal fixation.

Age:

The age of the patients ranged from 15 to 41 years, with an average of 24 years. Most patients were aged between 16 and 20 years old.

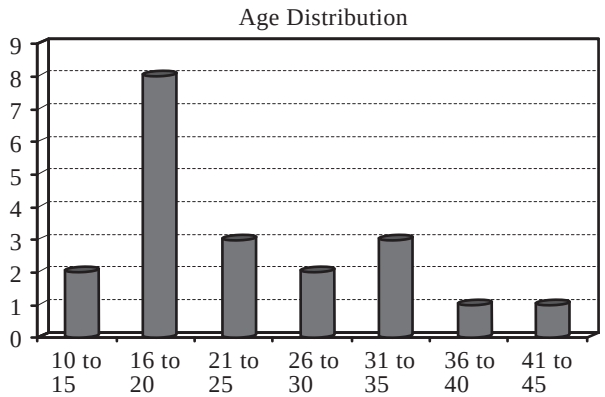

Fig. (1): Age distribution.

Gender:

In this study all patients presented to us were males except for one female patient.

Aetiology:

The causes of mandibular fractures in this study varied from road traffic accidents, fall from height, interpersonal assault, and sports related injuries. The leading cause was road traffic accidents accounting for 75% of the twenty cases presented to us.

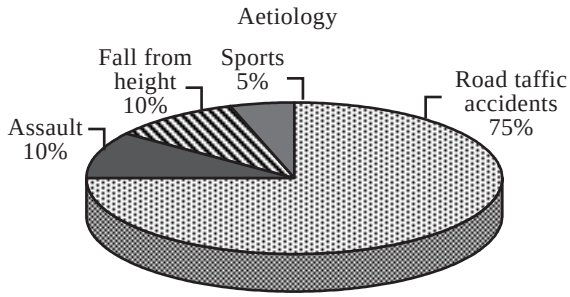

Fig. (2): Causes of mandibular fractures in the study.

In this study 17 cases out of the twenty were isolated maxillofacial trauma patients. 3 cases were polytrauma patients, one of them suffered from fracture skull base involving the middle cranial fossa and the other two patients suffered from femur fracture in one of them and the other had humeral fracture.

Table (2): Pattern of injuries.

Number of patients	Pattern of injury
17	Isolated maxillofacial injury
1	Neurological insult
2	Orthopedic intervention

Other Maxillofacial injuries:

In this study 3 out of the twenty cases had other fractures in their facial bones besides the mandible. 1 case had fracture of the zygomatico-maxillary buttress, 1 case had fracture of the inferior orbital rim, and one case had tripodal fracture of the zygoma. All fractures were in place and were treated conservatively except for the case of tripodal fracture that was treated by fixation of the infraorbital rim, zygomatico-maxillary, zygomatico-frontal fractures together with fixation of the mandibular fracture.

Total number of fractures:

In the twenty cases presented to us they had the total of 32 fractures, they included symphseal, parasymphseal, anterior body, posterior body, angle, ramus, subcondyle, and wide lamellar fractures.

Table (3): Type and percentage of mandibular fractures.

Fracture site	Number of fractures	Percentage %
Symphysis	5	15.6
Parasymphysis	10	31.2
Anterior body	2	6.2
Posterior body	1	3.1
Angle	6	18.7
Ramus	3	9.3
Condyle	4	12.5
Lamellar	1	3.1
Total	32	

Fractures fixed by three-dimentional plating technique:

Out of the total 32 fractures in this study, 23 fractures were fixed by using 3D plating technique. That was contributed to technical difficulties in application in certain fractures.

Table (4): Percentage of fixation using 3D plates.

Fracture site	Total number	No. of 3D plating technique fixation	Percentage of 3D plating fixation
Symphysis	5	5	100
Parasymphysis	10	10	100
Anterior body	2	2	100
Posterior body	1	1	100
Angle	6	3	50
Ramus	3	1	33.3
Condyle	4	0	0
Lamellar	1	1	100
Total	32	23	71.9

Bone healing:

In the 6th week postoperative visit, a panoramic view radiograph was done and compared to the immediate postoperative one. The images were assessed for evidence of bone healing. The shrinkage of the fracture line was taken as an evidence of bone healing, and the presence or absence of callus was used to distinguish between secondary and primary bone healing. In our study all patients showed evidence of callus-free bone healing, and no cases suffered from nonunion or malunion.

Complications:

One patient presented, in the 1st week postoperative visit, with slight degree of malocclusion, Fortunately the arch bars were still in place and the condition was managed conservatively by putting him back in occlusion with the aid of guiding traction elastics.

Another case suffered from mental nerve avulsion due to involvement of the mental foramen and it was hanging on a thin branch that did not stand the manipulation. One patient in the 1st week visit suffered from loss of sensation on one side of his lower lip and chin area, but he completely recovered after six weeks .There was no infection or wound dehiscence in any patient postoperatively. None of the patients showed fracture mobility postoperatively. No patients showed plate fracture on the radiographs postoperatively.

Table (5): Complications.

Complication	Number of cases
Wound infection	0
Wound dihescence	0
Nerve affection	2
Malocclusion	1
Lost teeth	2
Hardware failure	0
Total	5

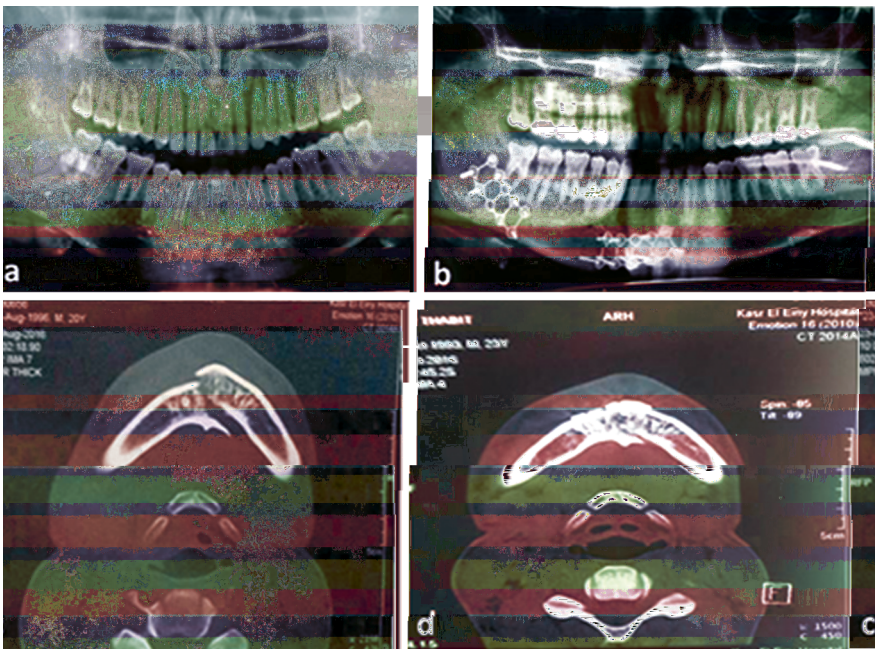

Fig. (3): (a) Preoperative panoramic view showing symphyseal fracture and Rt angle fracture. (b) Postoperative panoramic view after fixation of both fractures with 3D plates. (c) Preoperative axial CT scan. (d) Postoperative axial CT scan.

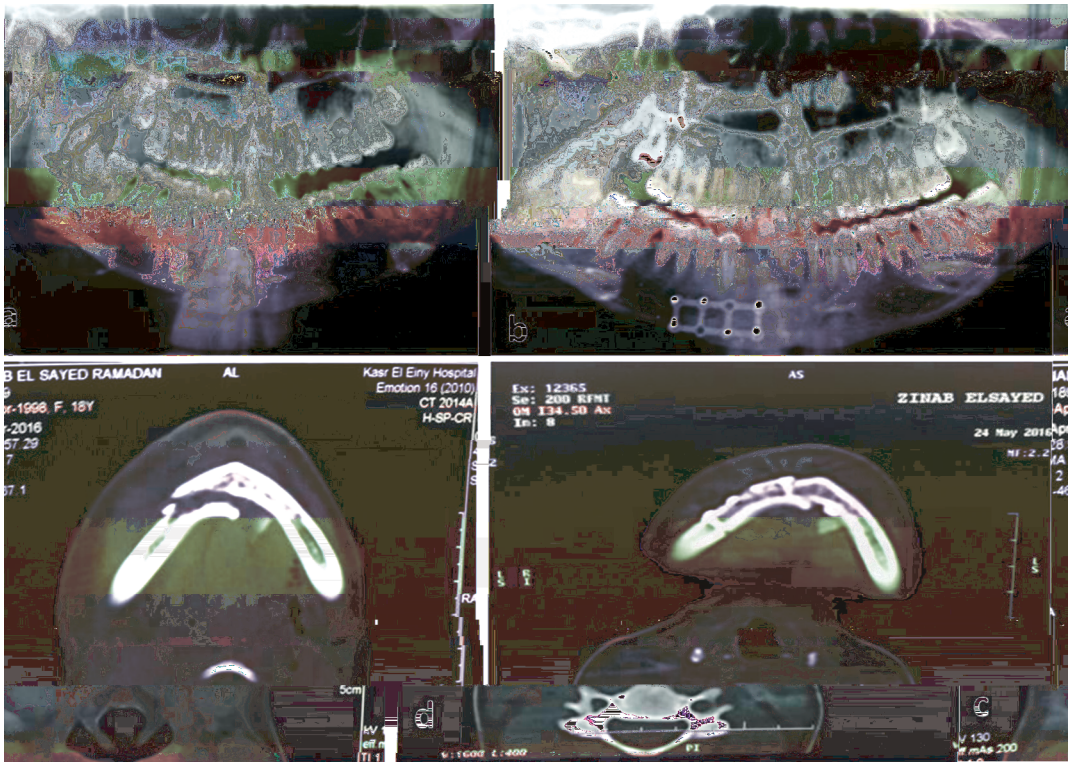

Fig. (4): (a) Preoperative panoramic view of a 22 year old female patient showing Rt parasymphyseal fracture. (b) Postoperative panoramic view. (c) Preoperative axial CT scan. (d) Postoperative axial CT scan.

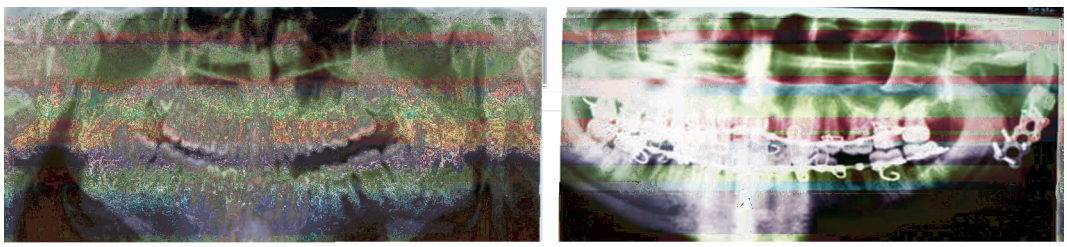

Fig. (5): (a) Preoperative panoramic view of a 26 year old male patient showing fracture of Lt ramus. (b) Postoperative panoramic view after fixation with 3D plate. (c) Preoperative coronal CT scan. (d) Postoperative coronal CT scan.

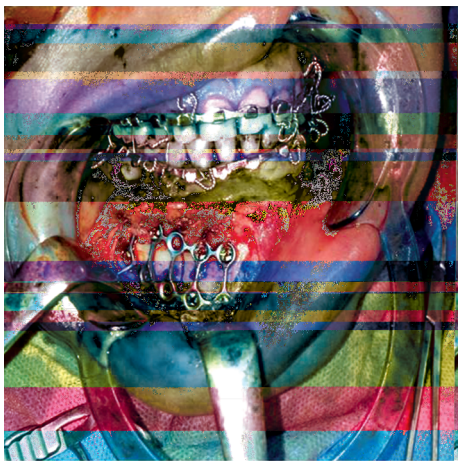

Fig. (6): Intraoperative photo following fixation of Rt parasymphyseal fracture with 3D plate.

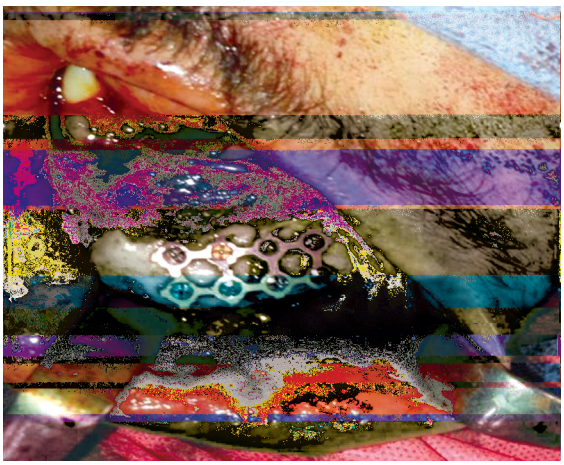

Fig. (7): Fixation of Lt body fracture with 3D plate.

Fig. (8): Fixation of Rt parasymphyseal fracture with 3D plate.

DISCUSSION

Mandibular fractures represent a common presentation at our emergency department. Mandibular fractures account for approximately two thirds of all facial fractures with a nearly 70% incidence. When comparing the ratio of incidence with other facial bones, mandible: Zygoma: Maxilla, it takes the lead with 6:2:1.5 proportion **[7]**.

The mandible is the only mobile part of the facial skeleton, and it houses the lower teeth in its alveolar part and its motion is essential for mastication. Accordingly adequate management of mandibular fractures is a must for safe rehabilitation and early return to daily activities without any limitations regarding the patient's lifestyle or special habits **[5]**.

The first attempts of open reduction of mandibular fractures dates to 1869. With the development of plate and screw system in orthopedic surgery, they presented a promising tool for internal fixation of mandibular fractures. After Luhr utilized that plating system in management of mandibular fractures in 1968, open reduction and internal fixation started to gain popularity and reliability as an alternative to closed reduction **[9]**.

Then the emergence of the two parallel schools of mandibular internal fixation took place and their influences are still evident till now in the modern maxillofacial practice and mandibular fixation. The German school that advocates high levels of rigidity which is generated by large compression plates, and the French school that advocates a functionally stable fixation achieved by smaller adaptable miniplates placed along ideal lines of osteosynthesis neutralizing the tension forces across a fracture line.

Farmand et al., in 1992, developed the concept of 3D miniplates. Their shape is based on the principle of the quadrangle as a geometrically stable configuration for support. Since the stability achieved by the geometric shape of these plates surpasses the standard miniplates, the thickness can be reduced to 1mm. The basic form is quadrangular with 2x2 hole square plate and 3x2 or 4x2 hole rectangular plate. The 3D miniplates itself was a misnomer as the plates themselves were not 3-dimensional, but holds the fracture segments rigidly by resisting the 3-dimensional forces namely shearing, bending and torsional forces acting at the fracture site **[2]**.

Farmand put three principles of 3D plate osteosynthesis.Tissue dissection should only be done in the vicinity of the planned osteotomy or fracture line. This does not disturb the blood supply to the fragments. 3D plates are positioned so that the vertical bars are parallel to the osteotomy or fracture line. The transverse bar of the plate should be

positioned perpendicular to the osteotomy or fracture line **[1]**.

In this study, we managed 20 cases that presented to us with mandibular fractures at Kasr Al-Ainy Emergency Plastic Surgery Department. Out of the total of 32 fractures we successfully applied the 3D plating technique in 23 fractures at different sites of the mandible.

Many advantages of 3D-plating technique have elaborated from this study. These advantages include easy application, simplified adaptation to the bone without distortion or displacement of the fracture, simultaneous stabilization at both superior and inferior borders resulting in shorter operative time and improved biomechanical stability.

In this study, not a single patient treated by 3-D plate developed infection or plate failure, which is not in accordance with Zix et al., in 2007, who reported 1 patient with fractured 3-D plate that occurred due to reduced inter-fragmentary cross-sectional bone surrounding the fracture site after extraction of molar tooth in angle region, leading to higher torsional forces **[4]**.

In the angle region where horizontal and vertical rami of mandible meet and where powerful elevator muscles are attached to the ramus, strong distractive forces are created; therefore, to counteract these forces, a strong fixation device is required (6). In this study, the advantage of 3-D plating system over conventional 2-D miniplates comes from the fact that the screws of the 3-D plates are placed in the box configuration on both sides of the fracture rather than on a single line. Also, a broad platform is created that may increase the resistance to the torsional forces along the axis of the plate.

The occlusion of patients was checked preoperatively and during the follow-up stages after surgery. In the present study, 19 patients treated by 3D plate osteosynthesis had normal premorbid occlusion and only 1 patient had postoperative occlusal discrepancy which was treated successfully by putting him back into occlusion using traction elastics.

3D plating technique has shown to offer high degree of rigidity, absolute mechanical stability that did withstand the mechanical loads of the mandible during the early postoperative period. This mostly obviated the need for postoperative maxillo-mandibular fixation, thus it shortened the rehabilitation period and facilitated the early return to daily life activities.

Anterior mandibular fractures that include the symphseal and parasymphseal regions occupied greater portion of our study over other sites in the mandible. In symphyseal, parasymphyseal and anterior body fractures, the ease of access and the surplus amount of bone makes almost any fracture in the site a candidate for 3D plating technique.

A claimed limitation of using 3D plating system is for fractures near the mental foramen where the mental nerve hinders the placement of the 3D plate. However this could be overcome by cutting one of the vertical bars of the 3D miniplate so the mental nerve can pass through the plate safely.

In fractures that involves the angle region, 3D miniplates can effectively fix the fracture with stable fixation, less incidence of complications **[8]**. An advantage of 3D miniplates in angle fractures compared to conventional miniplates is that they offer fixation with two rows across the fracture through the intra oral approach alone. While in the case of conventional miniplates; to have fracture fixation with 2 plates yone should either use the extra oral approach or use transbuccal retractors.

Zix et al., in 2007 conducted a study to evaluate the use of straight and curved 3-dimensional titanium miniplates for fracture fixation at the mandibular angle on 20 patients and concluded that the curved 3D plate can be considered more stable,less incidene of plate rupture and possibly more safe for fracture fixation than the straight plate **[4]**.

All the patients in this study experienced early recovery of normal jaw function, primary healing and good union at the fracture site with minimal weight loss thanks to early restoration of the masticatory function. There was great patient acceptance of this treatment plan.

A proposed disadvantage of 3D plates is excessive implant material resulting from extra vertical bars incorporated for countering the torque forces. However in this study, there was no statistically significant increase in the complication rate which may point out that this is most probably a theoretical risk.

None of the condylar fractures in this study was fixed by 3D plates as they were all managed conservatively. This may be the focus of another study to be conducted in the future because, to the best of our knowledge, there is not a clinical study till now that tested the efficacy of 3D plating in the management of condylar fractures.

Conclusion:

In this study, the use of 3D plating for management of mandibular fractures has proven to be safe, beneficial and efficient. It led to reduction in the operative time in addition to sound mechanical stability at the fracture site which nearly obviated the need for postoperative maxillo-mandibular fixation. This enabled the patients to return rapidly to their normal life. Simplicity and ease of application are great advantages.

REFERENCES

1- Farmand M.: The 3-dimensional plate fixation of fractures and osteotomies. Facial Plast. Surg., 3: 39, 1995.

2- Farmand M.: The 3-D plating system in maxillofacial surgery. J. Oral Maxillofac. Surg., 51: 166, 1993.

3- Babu S., Parmar S., Menat M., Raghani and Kapadia T.: Three dimensional miniplate rigid fixation in fracture mandible. Journal of Maxillofacial and Oral Surg., 6 (2): 14-16, 2007.

4- Zix J., Lieger O. and Iizuka T.: Use of straight and curved 3-dimensional titanium miniplates for fracture fixation at the mandibular angle. J. Oral Maxillofac. Surg., 65: 1758, 2007.

5- Jain M.K., Manjunath K.S., Bhagwan B.K. and Shah D.K.: Comparison of 3-dimensional and standard miniplate fixation in the management of mandibular fractures. J. of Oral Maxillofac. Surg., 68 (7): 1568-1572, 2010.

6- K.V, Lalitha R.M., Prasad K., Ranganath K., Shwetha V. and Singh J.: A comparitive evaluation between single non compression titanium miniplate and three dimensional titanium miniplates in treatment of mandibular angle fracture – a randomized prospective study. J. Craniomaxillofac. Surg., 41: 103-109, 2013.

7- Mittal G. and Dubbudu R.R.: Three dimensional titanium miniplates in oral and maxillofacial surgery: A prospective clinical trial. J. Maxillofac. Oral Surg., 11 (2): 152-159, 2012.

8- Alkan A., Celebi N., Ozden B., Bas B. and Inal S.: Biomechanical comprison of different plating techniques in repair of mandibular angle fractures. Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod., 104: 752-6, 2007.

9- Chrcanovic B.R.: Fixation of mandibular angle fractures: Clinical studies. Oral Maxillofac. Surg., 18: 123-52, 2014.