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Management of Anterior Mandibular Fractures Using Three Dimensions Mini-Plates

Ahmed Mohamed Atef [1], Amr Ali El swify[2] , Osama Antar Adly[3] ,Mohamed Hassan Eid [4], Ahmed Mohamed Abo El Naga [5]

[1](Assistant Lecturer, Oral and maxillofacial Surgery Department, Faculty of Dentistry / Beni-Suef University, Beni-Suef ,Egypt)

[2](Professor, Oral and maxillofacial Surgery Department, Faculty of Dentistry / Suez Canal University, Ismailia, Egypt)

[3](Professor, Plastic Surgery Department, Faculty of Medicine /Suez Canal University, Ismailia, Egypt)

[4](Lecturer, Oral and Maxillofacial Surgery Department, Faculty of Dentistry /Suez Canal University, Ismailia, Egypt)

[5](Lecturer, Plastic Surgery Department, Faculty of Medicine /Suez Canal University, Ismailia, Egypt)

Abstract:

Background*: Recently, oral and maxillofacial surgeons are favouring three-dimensional (3D) miniplates to treat mandibular fractures.*

Aims: *The aim of the study is to evaluate the efficacy of 3D-Stainless Steel miniplates in the management of anterior mandibular fracture.*

Materials and Methods: *Ten patients with anterior mandibular fractures were treated by open reduction and internal fixation using stainless steel 3D miniplates. Postoperatively patients were analyzed at the 1st week, 6th week, 3rd month and 4th month according to Uglesic V scoring system, 1993. Evaluating occlusion, mobility of fracture segment, wound dehiscence, neurological deficit, and infection.*

Statistical Analysis Used: *Statistical analysis performed using the computer program SPSS software for windows version 22.0 (Statistical Package for Social Science, Armonk, NY: IBM Corp) at significant levels 0.05 (P- Value ≤0.5).*

Results *The mean duration of plate adaptation to definitive fixation (PA-DF Interval) was 24.7 minutes, 3 patients (30%) had difficulty of adaptation at symphysis region, and there was need of supplemental IMF for 3weeks in four patients. According to Trismus index (mm), the patient ranged 29 to 38 with mean 33.2 .Occlusion was not the same before fracture in 30% of patients after interval of 3 month but after 4 month the occlusion become normal after selective grinding. With regards to Complication Scores two patients had soft tissue infection at 1st week.*

Conclusion: *3D plates in anterior mandibular fractures give dimensional stability and carry low morbidity and infection rates.*

Keywords: *3D Stainless Steel mini plates; Osteosynthesis; Mandibular Fractures, infection.*

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I. Introduction

The mandible is the third most fractured bone of the face. Of these fractures, approximately 20-35% are at the condyle and ramus, 20-30% at the angle, 15-30% at the body, 8-20% at the symphysis, and 1-5% at the alveolar ridge. [1]

The treatment of mandibular fractures has been in a constant state of evolution over the past few decades, with the optimal management of anterior mandibular fractures continuing to change. Although the techniques of fracture management have changed it significantly, the goals have not. Accurate reduction of the fractures, maintenance of premorbid occlusion, and early return to function are the keys to successful management of these fractures. [2]

Rigid fixation can be achieved by compression plates, however, they have many disadvantages.[3, 4] Preference should be given to a plate which is not a compression plate but still gives

enough rigidity to fractures. Michelet in 1973, ended the search for simple osteosynthesis that would guarantee fracture healing without compression which was modified, developed and put to practical use by Champy's in 1978 .[(1)]

While Michelet and Champy's study was based on two-dimensional (2D) models which took only bending and torsional forces into account [5]) a more recent study shows at a given point in fracture site, there are three forces acting on the mandible namely; bending, torsional, and shear[6] . A three-dimensional (3D) stainless steel plate is based on the principal of a quadrangle, as a geometrically stable configuration for support [7, 8]. Interconnections of the plate reduce the vertical displacement and shearing of the bone to minimal. Hence, intermaxillary fixation can be avoided completely [9]. The term 3D mini-plates itself is a misnomer as the plates themselves are not 3D, but hold the fractured segments rigidly by resisting the 3D forces namely shearing, bending, and torsional acting on the fractured site in function.

II. Patients and Methods:

Clinical trial carried out in department of oral and maxillofacial surgery Suez Canal University after obtaining ethical and research committee approval. Informed consent obtained and patients have selected from Suez Canal University hospital department of general surgery.

Ten patients were treated by open reduction and internal fixation using 2‑ mm 3D stainless steel plates (S. KU. Surgicals, Pune, India).

Inclusion criteria:-

-Both genders

-Patients with the age group 18–50 year

- Isolated displaced non comminuted anterior mandibular fractures will be included.

Exclusion criteria:

-Patients below of the age of 18 years.

-Grossly comminuted fractures

-Presence of evidence of infection

-Medically compromised patients.

-Severely lacerated soft tissue and risk of implant exposure is present

-Coronoid process fractures

-Severely atrophic edentulous mandible.

-Patients with less mandibular vertical height between root apex of teeth and lower border of mandible presuming that 3D plate will not fit. (Vertically short mandible.

III. Preoperative evaluation

The aetiologic causes of the patients condition varied from road traffic accidents, fall from height, assault and sport related injury. After completing their trauma surveys and stabilization of their conditions patients were transferred to the plastic emergency department for proper evaluation and preparation for surgery. After transfer to the plastic surgery unit all patients will set for antimicrobial regimen that include third generation cephalosporin (Ceftriaxone) 1gm twice-daily. Pain control was achieved by parental paracetamol. Patients were also instructed to lie in bed with head elevation 45° angle to reduce facial oedema.

Laboratory work up

All Patients had blood samples withdrawn on admission as part of their peri-operative preparation. Samples were analysed for:

-Complete blood picture

-Coagulation profile Prothrombin Time (PT)

-Partial ThromboPlastin Time (PTT)

-International Normalized Ratio (INR)

-liver functions test and renal function tests

-Fasting blood glucose level

Imaging

Patients were sent for CT scanning of the facial bones (axial and coronal cuts, with 3D reconstruction).patients were sent in the following day of surgery for panoramic radiographs then after four and six weeks.

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 were explained to the nature of their condition and the treatment options available. A written consent clarifying their condition was taken 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.).

IV. Operative procedure:

Anaesthesia

All procedures in the study were done under general anaesthesia. Nasal endotracheal intubation with pack insertion was performed to clear the oral cavity allowing for proper assessment of the patient's occlusion and fixing the fractures while the teeth were in their pre- injury bite.

Position

Patients were placed in supine position with the head fitting in a suitable size 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 was done and application maxillo-mandibular fixation was done if needed to maintain the occlusion during the procedure. In this study the used methods for MMF were Erich Arch bars, inter-maxillary screws and Ivy eyelet loopes depending on the nature of the fracture.

Incision

Preparation of 50ml solution containing 40ml adrenalized saline with the concentration 1:200,000 and 10ml of lidocaine 2% was infiltrated prior 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 facilitating its subsequent closure. Sub periosteal dissection of the mentalis muscle then the mental neurovascular bundle was encountered, care was taken not to injure the bundle and controlled dissection of the bundle was done releasing it from the surrounding periosteum.

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. With the assistance of a flat periosteal elevator, it was gently introduced to the

fractured site and advanced with a slight back and forth movement till it frees the fractured segments and reaches the inner cortex. Afterwards the fractured hematoma was removed with a suction catheter and any soft tissue intervening 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 fracture segments were held together with the aid of bone holding forceps when feasible, it prevented further displacement while applying the fixation method. Now the fracture is properly reduced and held into place and ready for fixation.

Three dimensional plating technique (3D mini plates)

After stabilization of the fractured segments introduction of 3 dimensional plate was done. Fixation of the 3D plate was done with 2mm monocortical screws at the superior bar and bicortical screws at the inferior bar in such a way that a horizontal bar is perpendicular and a vertical bar is parallel to the fracture line. In the symphysis and para symphysis regions, the upper bar was placed in the sub apical position.

Fig. (1) fracture line

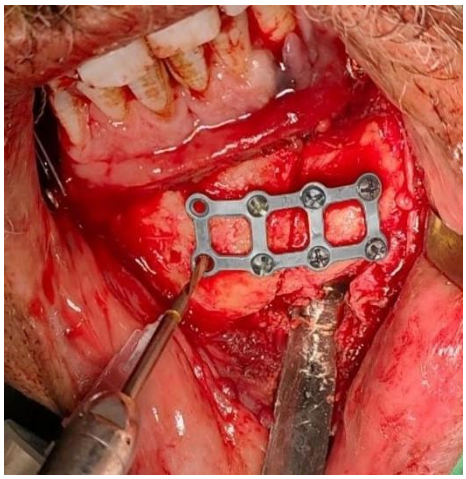

Fig.(2) placement of the plate

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 polygolic 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 in order if there is any bite disturbances during the postoperative period they can assist in putting in occlusion once again.

Postoperative care

Oral intake was restricted for the first 12 hours, during this period IV fluid replacement was scheduled. Then clear fluids were allowed followed by mouthwash.

The next day patients were sent for postoperative imaging. Postoperative imaging consisted of panoramic view radiograph facial bones including.

Discharge

All patients were discharged 24 hours after their 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. Postoperative visits were scheduled 1, 4, 6 weeks, three and four months postoperative.

If any arch bars or Ivy eyelets loops were left in the postoperative period they were removed on third week visit under local anaesthesia.

Preoperative assessment

1. Location and number of fractures in the mandible.
2. Associated soft tissue injuries (STI) were evaluated as
a. Single Abrasion = minimal STI
b. Multiple Abrasion +\- single cut Lacerated wound = moderate STI
c. Multiple cut lacerated wound = severe STI
3. Preoperative occlusion
4. Maximal interincisal opening (calibrated between incisal edge of central incisor of upper jaw and lower jaw with divider and transferred on scale in mm observed).
5. Any paraesthesia or anaesthesia of involved area (with the help of cotton wool, pin prick and an assessment of patient's objective feedback).
6. Presence or absence of displacement of the fractured segments. Displacement was seen at the inferior border with calliper scale on radiograph.
7. The displacement present was classified as-
a. 0mm to 2mm = mild Displacement.
b. 2mm to 5mm = moderate Displacement.
c. More than 5mm =severe Displacement.
8. Presence of teeth in the fracture line was assessed radio-graphically.
9. Duration between trauma and definitive treatment (IT-DF) noted

Intraoperative assessment:

1. Reduction approach (intraoral or extra oral)
2. Implant material used (Titanium or stainless steel).

3. Hardware complications (difficulty in plate bending \ breakage of plates)
4. Time duration for fixation of 3D bone plates from plate adaptation to last screw fixation (PA-DF).

Postoperative assessment:

1. Need for any supplemental method of fixation (IMF\Elastics).
2. Maximal interincisal opening (calibrated between incisal edge of central incisor of upper jaw and lower jaw with divider and transferred on scale in mm observed distance in mm).
3. Any paraesthesia of the involved area (with the help of cotton wool, pin prick and an assessment of patient's objective feedback).

According to Treatment Scoring System developed by Uglesic V. [10]

1. Occlusion and chewing in the 3rd and 4th month postoperatively (by surgeon's evaluation and self-evaluation).
2. Complications (soft tissue infection, Trismus, mobile fracture fragments, and bone infection) at the interval of 1st week, 6th week, 3rd month 4th month postoperatively were observed. The criteria and scoring parameters given in the system are described below.

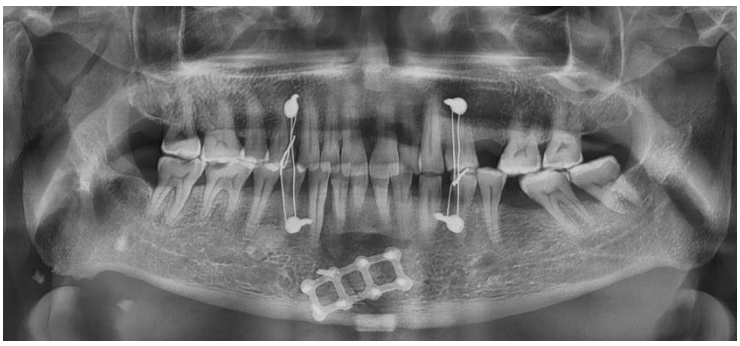

Fig (3) panoramic view for the fracture and plate in place

V. Results

Preoperative Details. (Table 1)

The main age in the study was 30.19 years ranged from 21-40 years. According to gender, the majority of patients were males.

The most common aetiology was RTA, Most of the patients had their main chief complaints pain in Jaw and difficulty in chewing and Pain in Jaw and difficulty in opening .and pain in Jaw and bleeding from mouth. Most of the patients had mandibular fracture type compound Intra orally (CI) and one patients had Compound Extra orally (CE).

The degree of displacement and soft tissue injury in most patients was minimal to moderate except one patient was severe.

The (IT-DF) interval ranged from one to four days for all patients. Regarding to occlusion in the most patients was deranged except two patients

Trismus index was ranged from 23-32 with average 28.2. In most patients, the fracture site was right parasymphysis, left parasymphysis, symphysis and left para symphysis with right subcondylar fractures.

Table 1: Preoperative Details of Patients. The table shows Age, Sex distribution, Aetiology, Chief Complaint, Type of fracture, Displacement, Soft Tissue Injury, Duration between initial trauma & definitive fixation (IT-DF Interval), Occlusion, Trismus Index and Site of fracture. Intra-operative Details of Group (A) and (B): (Table 2)

S.N	Age	Sex	Aetiology	Chief complaint	Type of mandibular fracture	Degree of Displacement	Soft Tissue Injury	IT-DF Interval	Occlusion	Trismus Index(mm)	Site of Fracture
S1	21	F	RTA	Pain in Jaw+ difficalty in	CE	Minimal	Minimal	3 day	Normal	23	Left para symphysis +Right sub condylar
S2	29	M	Fall	Pain in Jaw+ difficalty in open	CI	Minimal	Moderate	2 days	Normal	25	Left para symphysis+Right sub condylar
S3	38	M	RTA	Pain in Jaw+ difficalty in	CI	Minimal	Minimal	1 day	Deranged	30	right para symphysis
S4	32	M	RTA	Pain in Jaw+ difficalty in	CI	Moderate	Minimal	3 day	Deranged	32	symphysis
S5	24	M	RTA	Pain in Jaw+ difficalty in	CI	Moderate	Moderate	4 days	Deranged	33	Left para symphysis
S6	26	M	RTA	pain in Jaw	CI	Minimal	Moderate	2 days	Deranged	29	symphysis
S7	40	M	Assault	pain in Jaw+ bleeding from	CI	Minimal	Minimal	3 days	Deranged	32	Left para symphysis
S8	27	M	RTA	Pain in Jaw+ difficalty in	CI	sever	sever	1 day	Deranged	25	Left para symphysis
S9	42	M	Assault	Pain in Jaw+ difficalty in chew	CI	Moderate	Minimal	2 days	Deranged	31	Left para symphysis+Right sub condylar
S10	30	M	RTA	Pain in Jaw difficalty in open	CI	Moderate	Moderate	2 days	Deranged	22	Left para symphysis+Right sub condylar

The Surgical Approach was the same in all patients lower vestibular incisions. According to Other Associated Fractures, four patients has sub condylar fracture. The mean duration of plate adaptation to definitive fixation (PA-DF Interval) was 24.7 minutes. 3 patients (30%) had difficulty of adaptation at symphysis region probably because of prominent bony ridge and deranged occlusion.

Table 2: Intraoperative Details .Where ORIF was done using 3D stainless steel Plate. The table shows the Surgical Approach, Associated Fractures, Duration between 3D miniplate adaptation & complete fixation (PA- DF Interval) and Hardware Complications.

Serial No.	Surgical Approach	Other Associated Fractures	PA-DF Interval	Hardware Complications
S1	lower vestibular	Nil	23 mins	Non
S2	lower vestibular	right sub condylar	22 mins	Non
S3	lower vestibular	right sub condylar	26 mins	Difficulty
S4	lower vestibular	Nil	25 mins	Non
S5	lower vestibular	Nil	24 mins	Non
S6	lower vestibular	Nil	26 mins	Difficulty
S7	lower vestibular	Nil	25 mins	Non
S8	lower vestibular	right sub condylar	27 mins	Difficulty
S9	lower vestibular	Nil	24 mins	Non
S10	lower vestibular	right sub condylar	25 mins	Non

Post-operative details (Table 3)

There was need of supplemental IMF for 3weeks in four patients. According to Trismus index (mm), the patient ranged from 29 to 38 with mean 33.2 and statistical analysis showed improvement in mouth opening .With regards to Complication Scores, No patient reported any postoperative paresthesia/anesthesia .Two patients had soft tissue infection at 1st week.

For Surgeon's evaluations for occlusion:

At 3rd month, the occlusion of 3 patients were adequate on both sides but not the same as before injury. Slight alteration in occlusion postoperatively may be attributed to the associated fracture of subcondylar. All patients were re-evaluated at 4th month and occlusion rehabilitation was done by selective grinding. The patients were recalled again after 2 days for re-evaluation of occlusion.

Self-evaluations for occlusion:

At 3rd month, 5 patients were not satisfied at 3rd month. These finding were based on patient's perception only and on clinical correlation with surgeon's evaluation it was found to be true only in 3 patients. Patients in which surgeon's evaluation revealed that occlusion was satisfactory, were psychologically assured that, the occlusion was normal clinically and the feeling of altered occlusion was patient's faulty perception. All the patients were re-evaluated at 4th month. Out of 5 patients, 2 patients who were psychologically assured recovered and in remaining 3 patients occlusal rehabilitation was done. All the patients exhibited improvement in occlusion.

Self-evaluations for chewing: 5 patients were able to chew food from one side of jaw at 3rd month. But at 4th month 2 patients regained full chewing efficiency whereas, in remaining 3 patients improvement occurred after occlusion rehabilitation.

Table 3: Postoperative Details. This table shows the postoperative IMF/ELASTICS duration, Trismus Index, scores of Complications, Occlusion (surgeon & self-evaluation) at 3rd and 4th months and Chewing (self-evaluation only) at the 3rd and 4th months.

Serial No.	Postoperative IMF/ Elastics	Trismus index (mm)	Complication Scores				Occlusion (at 3 months)		Occlusion (at 4 months)		Chewing (at 3 months)	Chewing (at 4 months)
			1st week	6th week	3rd month	4th month	Surgeon Evaluation	Self Evaluation	Surgeon Evaluation	Self Evaluation	Self Evaluation	
S1	IMF for 14 days	29	0	0	0	0	5	-3	5	5	3	5
S2	Not given	30	-1	0	0	0	5	5	5	5	3	5
S3	Not given	35	0	0	0	0	3	-3	5	5	5	5
S4	Not given	35	0	0	0	0	5	5	5	5	5	5
S5	Not given	37	0	0	0	0	5	5	5	5	3	5
S6	IMF for 14 days	34	0	0	0	0	3	-3	5	5	5	5
S7	Not given	38	-1	0	0	0	5	5	5	5	3	5
S8	Not given	30	0	0	0	0	5	-3	5	5	5	5
S9	Not given	35	0	0	0	0	5	5	5	5	3	5
S10	Not given	29	0	0	0	0	5	-3	5	5	5	5
		Means 33.2	P=0.99ns				P=0.92		ns		P= 0.99 ns	

VI. Discussion:

This study was done on 10 patients, 9 were males and 1 was female patients. This male predominance might be due to the fact that men are commonly exposed to RTA and other trauma. RTA was the main etiology with 14 (70%) cases. This finding is in accordance with Schuchardt et al. who found RTA in 35.6% of cases. They suggested that strict formulation and implementation of traffic rules may reduce trauma due to RTA. Guimond et al. study showed different etiology for trauma dominated by assault (81.1 %), fall (10.8 %) and RTA (8.1 %). [11]

Evaluating of infection in our study showed that there was seen in two patients at first week all the patients were kept under antibiotic coverage and daily oral irrigation with Betadine solution. The low incidence of infection may be due to the stability afforded by the 3D Mini plates against torsional forces. After using 3D plates, Guimond et al., Feledy et al., and Zix et al. reported low infection rates of 5.4%, 9%, and 0%, respectively. Which match with our study, where infection rate reported was 20% in Group (B). [12, 13]

None of the patients had any intra oral wound dehiscence, infection, screw loosening and plate exposure post operatively except two patients had soft tissue infection at the first week. Which is in accordance with Jain et al and Kumari et al. [14, 15] in their study encountered 2/10 patients with infection in 3D stainless steel plating system which was treated with antibiotics; 2 patients out of 20 had wound dehiscence requiring re-suturing. None of the patients had to undergo plate removal due to the above mentioned reasons. Zix et al. had one plate fractured at 6th week follow-up period. (12)

The results suggest that fixation of mandibular anterior fracture with 3D plates provides 3D stability and carries low infection rates and shorter operative time because of simplified adaptation to the bone and simultaneous stabilization at both superior and inferior borders. As far as the cost–benefit ratio is considered, the single 3D plate costs less than Champy's plate as their reduction in the number of screws is 50%. The 3D mini plate system may be considered inconvenient to use in cases of oblique fractures and in fractures involving the mental nerve area. The other probable limitations of these plates could be the excessive implant material due to extra vertical bars incorporated for countering the torque forces, which is in agreement with Parmar et al. [16, 17]

Plate fracture was a most important complication in the study by Zix et al. Farmand and Dupoirieux had treated, 95 fractures of the mandibular body in which only one late infection and one plate fracture were reported (13),[8] , however in our study no such complications were encountered.

However, some amount of difficulty was experienced while adapting the 3D stainless steel plate in the symphysis region due to the excessive curvature. This finding is in accordance with Gupte et al.[18]

References

[1]. Motamedi, M.H.K., et al., Pattern of maxillofacial fractures: A 5-year analysis of 8,818 patients. 2014. 77(4): p. 630-634. doi:10.1097/ta.0000000000000369

[2]. Chiarelli, P.A., et al., 28 - Traumatic Skull and Facial Fractures, in Principles of Neurological Surgery (Fourth Edition), R.G. Ellenbogen, et al., Editors. 2018, Elsevier: Philadelphia. p. 445-474.e1.

[3]. Iizuka, T., et al., Infection after rigid internal fixation of mandibular fractures: a clinical and radiologic study. J Oral Maxillofac Surg, 1991. 49(6): p. 585-93. doi:10.1016/0278-2391(91)90340-r

[4]. Pogrel, M.A., Compression osteosynthesis in mandibular fractures. Int J Oral Maxillofac Surg, 1986. 15(5): p. 521-4. doi:10.1016/s0300-9785(86)80053-9

[5]. Kárász, I., L. Köröndi, and G. Szabó, Photoelastic stress analysis on mandibular osteosynthesis. Int J Oral Maxillofac Surg, 1986. 15(3): p. 259-62. doi:10.1016/s0300-9785(86)80082-5

[6]. Tams, J., et al., A three-dimensional study of loads across the fracture for different fracture sites of the mandible. 1996. 34 5: p. 400-5.

[7]. Wittenberg, J.M., et al., Biomechanical evaluation of new fixation devices for mandibular angle fractures. Int J Oral Maxillofac Surg, 1997. 26(1): p. 68-73. doi:10.1016/s0901-5027(97)80852-1

[8]. Farmand, M. and L. Dupoirieux, [The value of 3-dimensional plates in maxillofacial surgery]. Rev Stomatol Chir Maxillofac, 1992. 93(6): p. 353-7.

[9]. Smith, B.R. and J.V. Johnson, Rigid fixation of comminuted mandibular fractures. J Oral Maxillofac Surg, 1993. 51(12): p. 1320-6. doi:10.1016/s0278-2391(10)80135-1

[10]. Uglesić, V., et al., Evaluation of mandibular fracture treatment. J Craniomaxillofac Surg, 1993. 21(6): p. 251-7. doi:10.1016/s1010-5182(05)80042-3

[11]. Guimond, C., J.V. Johnson, and J.M. Marchena, Fixation of mandibular angle fractures with a 2.0-mm 3-dimensional curved angle strut plate. J Oral Maxillofac Surg, 2005. 63(2): p. 209-14. doi:10.1016/j.joms.2004.03.018

[12]. Zix, J., O. Lieger, and T. Iizuka, Use of straight and curved 3-dimensional titanium miniplates for fracture fixation at the mandibular angle. J Oral Maxillofac Surg, 2007. 65(9): p. 1758-63. doi:10.1016/j.joms.2007.03.013

[13]. Feledy, J., et al., Treatment of mandibular angle fractures with a matrix miniplate: a preliminary report. Plast Reconstr Surg, 2004. 114(7): p. 1711-6; discussion 1717-8. doi:10.1097/01.prs.0000142477.77232.f7

[14]. Jain, M.K., et al., Comparison of 3-dimensional and standard miniplate fixation in the management of mandibular fractures. J Oral Maxillofac Surg, 2010. 68(7): p. 1568-72. doi:10.1016/j.joms.2009.07.083

[15]. Kumari, M., et al., Comparison between Conventional 2.0 mm Miniplates versus 3-D Plates In Management of Mandibular Fractures. 2020.

[16]. Raghani, M., Three dimensional miniplate rigid fixation in fracture mandible. J Maxillofac Oral Surg, 2007. 6: p. 14-16.

[17]. Ravindranath, K., et al., Comparative Evaluation of Three-Dimensional Plating Systems in Maxillofacial Trauma: An Original Research. 2022. 14: p. S176 - S178.

[18]. Gupte, S.H., et al., Evaluation of Efficacy of Three-dimensional Stainless Steel Mini-Plates in the Treatment of Fractures of the Mandible: A Prospective Study. J Orthop Case Rep, 2016. 6(5): p. 35-40. doi:10.13107/jocr.2250-0685.620

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