Evaluation of 3-Dimensional Titanium Miniplates in Mandibular Fractures

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ABSTRACT

Introduction: Mandibular fractures are one of the most common fractures of facial skeleton because of its prominent position in maxillofacial region. Traditionally, surgeons have attempted to achieve: anatomic reduction, immobilization and fixation, prevention of infection and rehabilitation of function. The aim of our study was to evaluate the following parameters like surgical procedures, infection, hardware failure, wound dehiscence, neurosensoery deficit, and fate of implant.

Material and methods: The present study was conducted in the Department of Oral and Maxillofacial Unit, after obtaining ethical clearance. A total of 20 patients were selected to evaluate the usefulness of 3-Dimensional titanium miniplates in fixation of mandibular fractures. After surgical exposure, either straight 6 holed or 8 holed or curved 8 holed 3-D titanium miniplates are placed. The patients were in the age group of 21-40 years. Etiology of trauma in most of the patient was Road traffic accident (70%).

Result: The frequency of fracture site being mainly parasymphysis fracture (50%). Two patients had infection (10%). None of the patients had malunion or nonunion. The 3-Dimensional titanium miniplates are suitable for fixation of simple mandibular fractures and an easy to use alternative to conventional miniplates.

Conclusion: This plate is associated with good stability of fracture segments and low infection rate.

Keywords: 3-Dimensional Miniplates, Titanium, Mandibular Fractures, Open Reduction and Internal Fixation, Maxillomandibular Fixation.

INTRODUCTION

Mandible is the only mobile bone of the facial skeleton. Being a prominent bone of the facial skeleton, it is fractured most commonly among maxillofacial injuries. They may occur alone or in combination with other facial bone fractures.[1] The aim of the maxillofacial trauma treatment is the restoration of anatomic forms and function with particular care to re-establish occlusion to ensure a satisfactory union of the fragments and to prevent infection.[2] Today, Open reduction and Internal fixation can be achieved by variety of plating systems which uses both external and internal approach.[3]

Generally, mandibular fractures are treated with semirigid and rigid fixation. The rigid fixation is promoted by AO/ASIF principles in which a single solid plate fixed with bicortical screws, and in semirigid, monocortical miniplates are placed, along the Champy's ideal line of osteosynthesis. Both the techniques are associated with disadvantage. Rigid fixation is more difficult and time consuming adaptation to the bone. Semirigid fixation is not sufficiently stable for fractures that cannot be adequately reduced.[4] This shortcomings lead to the development of 3-Dimensional miniplates.[5]

3-Dimensional miniplates are geometrically closed quadrangular plate secured with bone screws. The shape is based on the principle of quadrangle as a geometrically stable configuration for support. The basic form of this plate is quadrangular with two 2-holed/3-holed/4-holed miniplates joined by interconnecting cross struts. The stability of these plates is achieved by their geometrical shape compared with standard miniplates.

In 1913, Lambotte recommended a geometrically closed quadrangular plate and found sufficient stability. This method did not give further popularity. In 1992 Farmand introduced the 3-Dimensional titanium miniplate system which has the advantage of creating three- Dimensional stability of the fractured segment. In combination with the screws monocortically fixed to the outer cortex, the rectangular plate forms a cuboid, which possesses a 3-Dimensional stability.[5,6] The biomechanical and technical constrains of the conventional rigid and semirigid fixation devices have lead to the current study, to evaluate the use of 3-Dimensiomal titanium miniplates in management of mandibular fractures. The aim of our study was to evaluate the following parameters like surgical procedures, infection, hardware failure, wound dehiscence, neurosensoery deficit, and fate of implant.

MATERIAL AND METHODS

This study was conducted in our Department of Oral and Maxillofacial unit, after obtaining institutional ethical clearance. A total of 20 patients with mandibular symphysis, parasymphysis, body and angle fractures were selected, to evaluate the usefulness of 3-Dimensional titanium miniplates in fixation of mandibular fractures. All cases were of road traffic accident, self fall and occupational hazards. Most of the patients were young adults except for two patients who were older than 40 years.

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The patients were evaluated preoperatively by recording the history of injury, past medical, dental, drug, personal history and general physical examination. Thorough clinical examination and radiological examination were done using orthopanthamograph. Routine biochemical and hematological investigations were carried out.

The preoperative data gathered included; age, gender, type of trauma and the duration from trauma to admission, to know about the pre operative infection.

Preoperative radiographic findings recorded was, status of dentition, presence of teeth in the line of fracture, fracture site, presence of additional fractures, any evident pathology and degree of fracture dislocation in angle fractures. All the patients were operated by a single team from the Department of Oral and Maxillofacial Surgery. Surgery was performed in a standard manner and patients were systematically followed up according to the prospective protocol.

All surgeries were performed under general anesthesia, except for two patients which was done under local anesthesia. Preoperatively, prophylactic antibiotics were given (I.V Cefotaxim 1 gm 12th hourly and Metronidazole 500 mg 8th hourly). Erich arch bar were placed for intra operative maxillomandibular fixation.

The fracture site was exposed through intra oral or extraoral approach for symphysis, parasymphysis, body and angle fractures respectively. Fracture fragments was reduced and fixed with both 6-holed, 8-holed straight, and 8-holed curved 3-Dimensional titanium plates. All the plates were placed near the tension trajectories of the mandible. The interconnecting cross struts was placed parallel and horizontal cross bars perpendicular to the fracture line.[15] (Fig IV)

Fixation was done by 2.0 mm diameter 8 mm length titanium screws. In every case the upper screws was tightened first followed by the lower one. Final tightening of screws done and occlusion was checked. Concomitant 6 cases of fronto-zygomatic fractures were fixed with 1.5mm and 2.0 mm diameter conventional stainless steel miniplates. Concurrent condylar and subcondylar fractures were treated by closed reduction, with post operative maxillomandibular fixation for 2-4 weeks.

Postoperatively antibiotics (I.V Cefotaxim 1 gm 12th hourly and Metronidazole 500 mg 8th hourly for three days followed by oral Amoxicillin 500 mg 8th hourly and Metronidazole 500 mg 8th hourly for five days) along with oral rinse was advised. Soft diet was recommended for six weeks. Patients were evaluated for pain, swelling, mouth opening, occlusion, neurosensory deficit, wound dehiscence, infection and plate exposure. Radiologically Orthopanthomogram was taken to evaluate the adequacy of surgical reduction and plate localization.

RESULTS

Out of 20 trauma patients selected, all were male patients in the age range of 18-50 years. The maximum number of patients were in the age group of 21-30 years (9 patients-45%), 7 patients were in the age group of 31-40 years (35%), 3 patients in the age group of 41-50 years (15%) and one patient was below 20 years (5%) (Fig-I).

Etiology of trauma in most of the patients was Road traffic accident (14 Patients - 70%), 4 patients were occupational (20%), one patient was self fall and one patient was assault (each of 5%) (Fig-II).

The frequency of fracture site was, parasymphysis fracture in 10 patients (50%), angle fracture in 4 patients (20%), Body fracture in 4 patients (20%) and Symphysis fracture in 2 patient (10%) (Fig-III). Among the 20 patients, 16 patients had fracture of anterior mandible and 4 patients had angle fractures, out of which 6 had associated fractures of condyle and zygomatic complex. All the patients were dentate, except two were partially edentulous. The mean interval from trauma to surgery was 4.8 days (Table-I). Out of 16 anterior mandibular fractures, 5 fractures were treated

Type		N	Mean	Standard deviation	Standard error of mean
Duration from trauma to admission		20	4.8	2.37	0.61
Pain (VAS) at the time admission		20	4.9	1.62	0.42
Swelling (In mm)	Antero-postrior	20	22.33	12.94	3.34
	Supero-inferior	20	20.67	11.47	2.96
Mouth opening(in mm)		20	21.13	4.85	1.25

Table-1: Pre-operative Parameters.

Type		N	Mean		Standard deviation		Standard error of mean		t value	Sig
			before	after	Before	after	before	after		
Pain (VAS) at the time admission		20	4.0	0.2	2.1	0.56	0.54	0.14	7.33	HS P<0.001
Swelling (In mm)	Ante- ropos-trior	20	19.67	0.67	8.34	2.58	2.15	0.67	10.72	HS P<0.001
	Supe- roin ferior	20	19.67	0.67	8.34	2.58	2.15	0.67	10.72	HS P<0.001
Mouth opening (in mm)		20	19.87	40.07	3.15	1.28	0.82	0.33	21	HS P<0.001

Table-2: Post-Operative parameters (Paired samples t-test) (before and after operation).

Clinical and Radiological parameters	Mean	SD
Time required for plate fixation(mean min)	33.33	6.99
Wound gaping	0.13	0.35
Infection	0.13	0.35
Unstable occlusion	0.13	0.35
Radiological assessment (reduction / fixation)	-	-

Table-3: Clinical and Radiological parameters

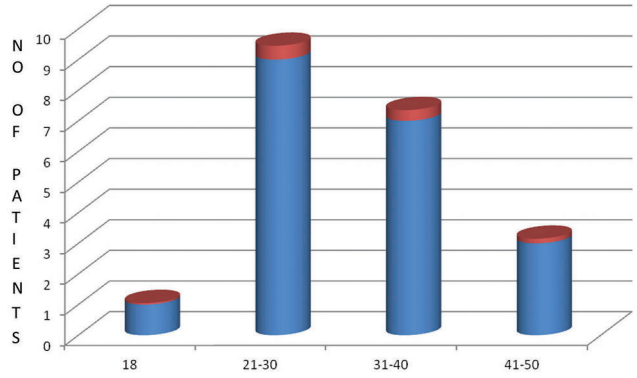


Figure-1: Age wise distribution of patients figure - ii: etiology of trauma distribution

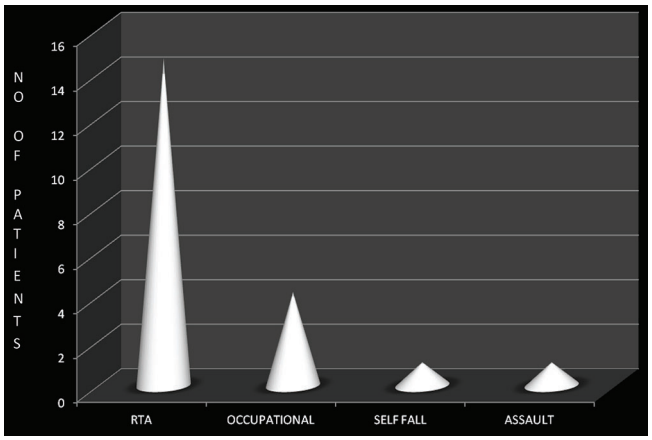


Figure-2: Etiology of trauma distribution

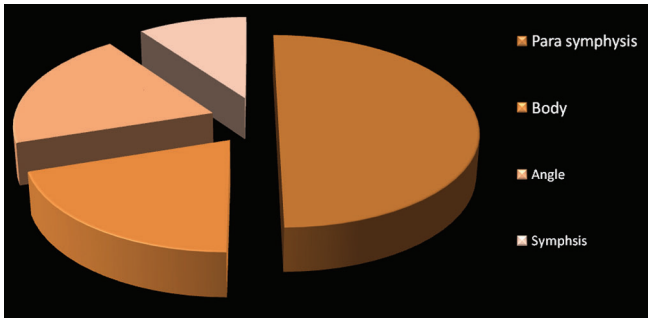
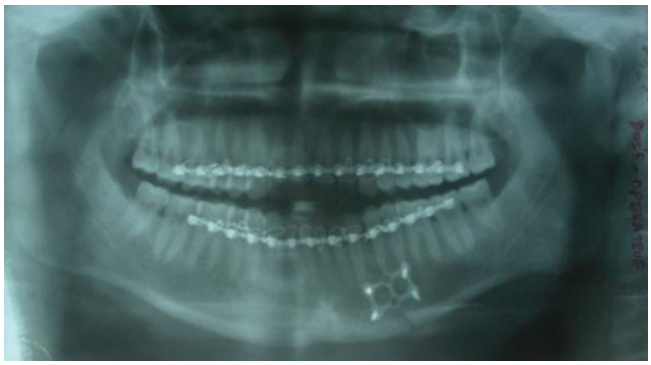


Figure-3: Incidence of fracture

with 8-holed straight, and 11 fractures were treated with 6-holed straight 3-D miniplates. Four of the angle fractures were treated with curved 8-holed 3-D miniplates. The other associated fractures were treated with conventional stainless steel miniplates.

The average time for plate fixation was 33.33 min. The mean operation time from incision to closure was 45-110 min (mean 65 min). Pre-operatively all the 20 patients



Figure–4: Post - operative radiograph

complained of pain. Post-operatively pain subsequently reduced by the end of one week. Except one patient had a surgical site infection, where pain was present in the second week. Pre-operatively all the 20 patients had swelling which reduced post-operatively by the seventh day ($p<0.001$). Hence pain and swelling were not statistically significant.

Pre-operatively 16 patients (80%) presented with occlusal disharmony and in 4 patients (20%) the occlusion was stable. Post-operatively 2 patients with associated condylar fractures were treated with MMF, for a mean period of 4 weeks. Other patients achieved occlusion with out MMF, however guiding elastics were placed post operatively in 4 patients for 2 weeks in order to adjust the occlusion. Hence all patients achieved occlusion by the first post-operative month.

Pre operatively mouth opening was limited to 19.87mm and post-operatively most patients achieved mean mouth opening of 40.07mm by the end of six months (Paired samples t-test) ($p<0.001$). (Table-II)

Out of 20 patients, in 14 anterior mandibular fractures, the mental nerve was indentified and protected before plate fixation. In one patient, the nerve was traumatized at the time of accident (5%). No neurosensory deficit was elicited in the rest of the 19 patients (95%).

Four patients with angle fracture had tooth in the line of fracture which did not require extraction. None of the patients had pre-operative infection

Post operatively, out of 20 patients, 18 patients (90%) had no infection, 2 patients developed infection (10%). In one of the patient infection occurred in the second post-operative week, which was a surgical site infection, in another patient infection developed six months later which was due to retention of foreign body (wooden piece). The foreign body was removed intraorally under local anesthesia. Both the patients were treated by standard protocol of incision and drainage and antibiotic therapy. Intraoral wound gaping was seen in 2 patients (10%) were resuturing was done and Betadine mouth gargle was advised. None of the patients had hardware complications. No cases of nonunion or malunion were recorded (Table-III).

DISCUSSION

The methods for open reduction for mandibular fracture have changed and diversified anonymously in recent years.[4]

Since the work of Michelet (1972) and later Champy (1975), miniplate osteosynthesis has become an important fixation method in Maxillofacial and Craniofacial surgery.[3] The requirements of ideal miniplate system is biocompatibility of the material, easy adaptation of the plates and stabilization of fractured fragments without dislocation of the fragments and impairment of the blood supply.[5] The advantages of miniplates in maxillofacial surgery is in relation to functional considerations such as jaw function, weight loss and pulmonary function.[6] Hence miniplate osteosynthesis alleviates the need for protracted periods of MMF and hence associated with few complications.[8]

In a review of 1067 patients by Kirk L Fridrich et al, found the greater number of fracture occurred in the age group of 20-29 years and sex distribution for male: female: 3: 1. Altercations were found to be the main cause of fractures followed by RTA. Angle fractures were most common constituting 26.7% of the total followed by condylar, symphysis and alveolar fracture.[9]

Farmand.M developed 3-Dimensional titanium plates and screws which he started using since 1990 which was relatively a new plating system. The basic concept of the 3-D fixation is based on the shape of the plates. A geometrically closed quadrangular plate, secured with bone screws, achieves stability in three dimensions.[5] Because stability is achieved by the geometric shape, compared with standard miniplates, the thickness of these plates is reduced to 1mm. The basic form is quadrangular 2X2 hole plate with square or rectangular segments; 3X2 or 4X2 hole miniplates are also available. The plates are adapted to the bone and are secured with monocortical self-cutting screws.[6]

In our study all the patients were treated with 6-holed and 8-holed straight and 8-holed curved 3-Dimensional titanium miniplates. This plate required less dissection of tissue, therefore, reduced time of operation (Mean of 65min). In a study done by Pamela J Hughes et al, J.Zix et al (65mins) and Feledy J et al (55mins) showed easier application, which was reflected in reduced average operating time.[4,10,11]

In our study, all the plates were made of grade II titanium with thickness of 1 mm and width of 1.5mm. In a study by J.Zix, used straight and curved 3-D titanium miniplate for fracture fixation at the mandibular angle, the width and thickness of the bars were 0.8 mm and 1 mm. Hence these types of plates can be easily contoured and adapted to the bony fragments. In a study done by Alper Alkan et al has advocated titanium as the metal of choice for fixation of plate mainly because of its high biocompatibility, ease of manipulation, and the potential for no second surgery.[8] In a pilot study conducted by L-E Moberg et al on metal release from 3 plates used in jaw fracture treatment, advocated, that elements released from the Ni-Cr and Co-Cr alloy implants are allergic sensitizers and their permanent retention after healing of the fracture is contraindicated. Titanium implants is to be preferred and not removed post-operatively.[12]

In our study the infection rate was 10% (2 out of 20). This is comparable to the infection rate in clinical studies on 3-D plates by Claude Guimond et al was 5.4% (2 out of 37) and by Feledy.J et al was 9% (2 out of 22).[4,11] The study done by Peter Bui is the first study to compare the infection rates between the presence and absence of tooth in line of fracture in mandibular angle fracture treated with 2.0mm 8-holed strut plate. In his study complication rate was 8.2% in treatment of uncomplicated mandibular angle fractures.[13]

One advantage of this 3-D plate is easy application and simplified adaptation to the bone without distortion or displacement of fracture, as well as simultaneous stabilization of both the superior and inferior borders, making 3-D plate the time saving alternative to conventional miniplate.[4] In our clinical study the horizontal cross bar was placed perpendicularly to, and vertical cross bar parallel to the fracture line. There by achieving good occlusal stability. J.M.Wittenberg et al also reported the advantage of reduced time for fixation of plate thereby allowing the patients to function immediately with the reasonable rate of success.[14]

Post-operatively only 2 out of 20 patients required MMF, these two patients had associated condylar fractures. There by allowing all the other patients (18 patients) to function immediately. Post-operatively all the patients achieved good mouth opening of 40.07mm. This was advocated by Farmand.M who reported a good stability against traction forces (90N) and torsion forces (30N) despite the small size and thickness of the plates.[5]

In our study one patient (5%) had neurosensory deficit related to the pre-operative traumatic injury occurred at the time of RTA in relation to mental nerve. This observation was also found in a study by J.Zix et al and J.M.Wittenberg et al, Claude Guimond et al who found that the main cause of sensory deficit in mandibular fracture was trauma itself. [4,11,14]

In our study, none of the patients were found to have hardware failure. J.Zix advocated the reason for hardware failure as, multiple bending and improper placement of the plate, as well as insufficient fracture reduction or over drilling of the screw holes which have negative effects on the stability of the fixation, resulting in a plate fracture. Another reason for the hardware failure is the reduced interfragmentary cross-sectional bone surface at the fracture site.[4,14]

None of the patients in our study had malunion or nonunion. In a series of biomechanical studies on mandibular fractures, Haug et al used 2.0mm matrix miniplate for mandibular angle fracture and found no cases of nonunion, malunion or plate failure and the matrix miniplate provided sufficient stability for fracture healing.[15]

CONCLUSION

The use of 3-D titanium plates in management of mandibular fractures stabilizes the fracture segment in three dimensions. It offers better interfragmentary stability when compared to other conventional plates.These type of plates can be easily adapted to the bone fragments. It requires less surgical exposure of the underlying fractured site.The plates used in our study were of 1.5mm width and 1mm thickness. Whereas in a study by J.Zix, the plate design had the width and thickness of the bars as 0.8 mm and 1 mm respectively, which resulted in the mechanical weakness of the lengthwise

bars. Hence the 3-D plates used in our study were found to have a good stability against traction and torsion forces, thereby preventing plate fracture. It carries low morbidity and infection rates that may prove to be comparable to the "gold standards" reconstruction plate. Hence we can conclude that 3-Dimensional titanium miniplates are suitable for fixation of mandibular fractures and an easy to use alternative to conventional miniplates.

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