A Comparative Study of 3-Dimensional Titanium Versus 2-Dimensional Titanium Miniplates for Open Reduction and Fixation of Mandibular Parasymphysis Fracture

Yogesh Mittal¹ · K. George Varghese² · S. Mohan² · N. Jayakumar² · Somil Chhag²

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Abstract

Introduction Three dimensional titanium plating system was developed by Farmand in 1995 to meet the requirements of semi rigid fixation with lesser complication. The purpose of this in vivo prospective study was to evaluate and compare the clinical effectiveness of three dimensional and two dimensional Titanium miniplates for open reduction and fixation of mandibular parasymphysis fracture.

Materials and Methods Thirty patients with non-comminuted mandibular parasymphysis fractures were divided randomly into two equal groups and were treated with 2 mm 3D and 2D miniplate system respectively. All patients were systematically monitored at 1st, 2nd, 3rd, 6th week, 3rd and 6th month postoperatively. The outcome parameters recorded were severity of pain, infection, mobility, occlusion derangement, paresthesia and implant failure. The data so collected was analyzed using independent *t* test and Chi square test ($\alpha = .05$).

Results The results showed that one patient in each group had post-operative infection, occlusion derangement and mobility ($p > .05$). In Group A, one patient had paresthesia while in Group B, two patients had paresthesia ($p > .05$). None of the patients in both the groups had implant failure. There was no statistically significant difference between 3D and 2D miniplate system in all the recorded parameters at all the follow-ups ($p > .05$).

Conclusion 3D miniplates were found to be better than 2D miniplates in terms of cost, ease of surgery and operative time. However, 3D miniplates were unfavorable for cases where fracture line was oblique and in close proximity to mental foramen, where they were difficult to adapt and more chances for tooth-root damage and inadvertent injury to the mental nerve due to traction.

Keywords Three dimensional titanium miniplate (3D) · Two dimensional titanium miniplate (2D) · Mandibular parasymphysis fracture · Open reduction and internal fixation

Introduction

The face serves a crucial role in human interaction and injuries to it result in devastating esthetic and functional sequelae. From the time of Hippocrates, physicians have described many different techniques for treating mandibular fractures, the principle of which has always been repositioning and immobilization of the bony fragments [1]. Treatment required the jaw to be immobilized for a prolonged period and patient had to be on liquid diet [2]. However changing society and reluctance of many patients to wear intermaxillary fixation for prolonged period forced surgeons to look for different methods which led to development of open reduction and internal fixation (ORIF). Several methods of ORIF have been used which include wire osteosynthesis, Luhr's vitallium compression plate, Schmoker and Spiessl's dynamic compression plate (DCP), eccentric dynamic compression plate (EDCP), reconstruction plate, monocortical noncompression miniplates, lag screw, and 3-dimensional (3D) plates [3, 4]. The main advantages of ORIF included avoiding intermaxillary

✉ Yogesh Mittal
dryogesh82@gmail.com

¹ Department of Trauma and Emergency, All India Institute of Medical Sciences (AIIMS), Jodhpur 342005, Rajasthan, India

² Department of Oral and Maxillofacial Surgery, Government Dental College, Kottayam 686008, Kerala, India

fixation (IMF) with its hazards to the airway, a more rapid return to normal function with a reduced incidence of weight loss and improved early jaw mobility. DCP, EDCP, Luhr's plate, reconstruction plate had a very high rate of complication such as malocclusion and infection. They also required an extraoral approach and are highly technique sensitive [5, 7]. While Champy's miniplates and lag screws require intra oral approach are less technique sensitive and produce consistently good result with regard to occlusion [6]. Miniplates scored over lag screws for the ease of applications and have become more popular among maxillofacial surgeons. Recently, modifications in miniplates like titanium three dimensional (3D) plating system has been developed to meet the requirements of semi rigid fixation with lesser complications. The geometry of 3D plates conceptually allows for stability in three dimensions, and resistance against torque forces while maintaining a low profile and malleability. Unlike compression and reconstruction plates, their stability is not derived from the thickness of the plate but from configuration. In combination with the monocortical screws fixed to the outer cortex, the rectangular plate forms cuboids, which possess 3D stability [7, 8]. Because the design of the 3D plate is conceptually that of two linear plates connected by reinforcing vertical struts, strut plates may therefore provide greater resistance against gap opening at the inferior border with masticatory forces [9].

Patients and Methods

A prospective study was conducted on 30 patients who reported to the Department of Oral and Maxillofacial Surgery, Government Dental College and Hospital, Kottayam, Kerala India. A series of 30 patients with isolated mandibular parasymphysis fractures were randomly divided into two

groups, Group A: ORIF with one 2×2 hole 2 mm 3D titanium miniplate (15 patients) with four 2×6 mm titanium screws (Fig. 1), Group B: ORIF with two 2D titanium miniplates (15 patients) including first 4 hole miniplate with gap and second 2 hole miniplate with gap including six 2×6 mm titanium screws (Fig. 2). Patients were selected based on the following inclusion criterias, non-comminuted, non-infected mandibular parasymphysis fractures while mandibular parasymphysis fractures concurrent with angle, body, condylar and other facial fractures and medically compromised patients were excluded from the study. All patients were treated and observed by the same surgeon. All the patients' occlusions were achieved at the time of plate placement by intermaxillary fixation (IMF) and any obstruction to reduction were removed and IMF was released after plate fixation. In group A, 3D miniplates were used for reduction and fixation of mandibular parasymphysis fractures after intraoral vestibular incision (Fig. 3). While in group B, two 2D miniplates including first 4 hole plate with gap over lower border of mandible and second 2 hole plate with a gap of minimum 5 mm superior to first plate were placed for reduction and fixation of mandibular parasymphysis fractures after intraoral vestibular incision (Fig. 4). In the parasymphysis area where the fracture site was near the mental foramen, mental nerve was preserved by careful blunt dissection and retraction by nerve hook before fixing the plate and plate was placed above the nerve and to avoid the chance for tooth-root damage, holes were drilled monocortically directing them into the space between the roots. Post-operative OPG showed the 3D and 2D miniplates in mandibular parasymphysis fracture respectively (Figs. 5, 6).

For the patients assessment following parameters were evaluated, pain, infection, mobility between fracture fragment, occlusion derangement, paresthesia and implant failure. For post-operative pain assessment in the two Groups, American Academy of Physical Medicine and

Fig. 1 3D titanium miniplate

Fig. 2 2D titanium miniplate

Fig. 3 Fracture reduction and fixation by 3D titanium miniplate

Fig. 4 Fracture reduction and fixation by 2D titanium miniplate

Fig. 5 Post-operative OPG showing 3D rectangular miniplate

Rehabilitation pain level scale was used. The score of pain level scale from 1 to 10 was subdivided into four grades for the purpose of convenience. The patients with no pain were scored as Grade 0. A mere awareness of the pain by the patient but not bothering him which could be tolerated without medication was taken as mild pain and graded as Grade 1. The pain which could not be tolerated without medication was taken as moderate pain and graded as

Fig. 6 Post-operative OPG showing 2D rectangular miniplate

Fig. 7 Age distribution of patients (years)

Grade 2. The pain which could not be even tolerated with medication was taken as severe pain and was graded as Grade 3. Preoperative and postoperative paresthesia were tested with Von Frey hairs. Preoperative and post-operative mobility were assessed manually by using thumb and fourth finger and mandible was grasped on either side of suspected fracture and gentle manipulation was applied. All patients were followed up at 1st, 2nd, 3rd, 6th week, 3rd and 6th month. Data was statistically analyzed using the Statistical Package for Social Sciences (SPSS) version 16, independent *t* test and Chi square test.

Results

In the present study 30 patients with isolated mandibular parasymphysis [24 male (80 %) and 6 female (20 %)] were enrolled. Most common age group of patients were between 16 and 30 years (43 %) followed by 31–45 years (37 %) and 46–60 years (20 %) (Fig. 7). The most common etiology of fracture was road traffic accident (77 %) followed by assault (17 %) and fall (6 %) (Fig. 8). In the present study maximum number of patients were treated within time lapse of 4–7 days (73 %).

All the patients in Groups A and B had mild to moderate pain at the 1st week of follow-up. After this at routine follow-up from 2nd to 6th week pain intensity decreased. At 3rd and 6th month of follow-up none of the patients complained of pain in both the groups. There was no statistically significant difference in pain between two groups ($p > .05$) (Fig. 9; Table 1).

Fig. 8 Etiology of fracture

Fig. 9 Distribution of patients according to severity of pain

Table 1 Comparison between Group A and Group B in terms of severity of pain

	Group	N	Mean	SD	<i>p</i>
Pain 1 week	A	15	1.40	.632	.432
	B	15	1.60	.737	
Pain 2 weeks	A	15	.80	.676	.812
	B	15	.87	.834	
Pain 3 weeks	A	15	.40	.507	.754
	B	15	.47	.640	
Pain 6 weeks	A	15	.00	.000	.326
	B	15	.07	.258	
Pain 3 months	A	15	.00	.000	–
	B	15	.00	.000	
Pain 6 months	A	15	.00	.000	–
	B	15	.00	.000	

One patient each (6.7 %) had post-operative occlusion derangement which was noted at 1st week of follow-up in Group A and Group B. At 2nd week of follow-up, one patient had occlusion derangement only in Group A. Third week of follow-up onwards all patients had intact occlusion in both the groups (Fig. 10).

One patient each (6.7 %) had post-operative infection at 1st week of follow-up in Group A and Group B. Second week of follow-up onwards none of the patients reported with infection in both the groups (Fig. 11).

One patient in each group had post-operative fracture segment mobility at 1st and 2nd weeks of follow-up. These same patients also had concurrent soft tissue infection. At

Fig. 10 Comparison between Group A and Group B in terms of occlusal derangement

Fig. 11 Comparison between Group A and Group B in terms of infection

3rd week of follow-up, fracture fragment mobility in group A still persist. At the 6th week of follow-up onwards none of the patients had mobility at fracture site in both the groups (Table 2).

One patient in Group A and two patients in Group B reported with paresthesia of lower lip and chin region at all the follow-ups (Table 3). None of the patients had implant failure in Group A and Group B at all the follow-ups (Fig. 12). In the present study, 3D miniplates and 2D miniplates were compared at all follow-ups, but there was statistically no significant difference between the two Groups.

Discussion

Titanium is the material of choice for fixation plates, mainly because of its high biocompatibility and ease of manipulation. Modification of miniplates like titanium 3D plating system was developed by Farmand in 1995 to meet the requirements of semi rigid fixation with lesser complications. The 3D miniplates is a misnomer as the plates are not three dimensional but hold the fracture fragments rigidly by resisting the forces in three dimensions namely shearing, bending and torsional forces [6, 11]. The basic concept of 3D fixation as explained by Farmand (1995) is

Table 2 Comparison between Group A and Group B in terms of mobility

Follow up	Group A (N = 15)		Group B (N = 15)		χ^2	<i>p</i>
	Present	Absent	Present	Absent		
I (1st week)	1 (6.7 %)	14 (93.7 %)	1 (6.7 %)	14 (93.7 %)	.0	1 (NS)
II (2nd week)	1 (6.7 %)	14 (93.7 %)	1 (6.7 %)	14 (93.7 %)	.0	1 (NS)
III (3rd week)	0	15	1 (6.7 %)	14 (93.7 %)	1.03	.30 (NS)
IV (6th week)	0	15	0	15	–	–
V (3rd month)	0	15	0	15	–	–
VI (6th month)	0	15	0	15	–	–

Table 3 Comparison between Group A and Group B in terms of paresthesia

Follow up	Group A (N = 15)		Group B (N = 15)		χ^2	<i>p</i>
	Present	Absent	Present	Absent		
I (1st week)	1 (6.7 %)	14 (93.7 %)	2 (13.3 %)	13 (86.7 %)	.37	.543 (NS)
II (2nd week)	1 (6.7 %)	14 (93.7 %)	2 (13.3 %)	13 (86.7 %)	.37	.543 (NS)
III (3rd week)	1 (6.7 %)	14 (93.7 %)	2 (13.3 %)	13 (86.7 %)	.37	.543 (NS)
IV (6th week)	1 (6.7 %)	14 (93.7 %)	2 (13.3 %)	13 (86.7 %)	.37	.543 (NS)
V (3rd month)	1 (6.7 %)	14 (93.7 %)	2 (13.3 %)	13 (86.7 %)	.37	.543 (NS)
VI (6th month)	1 (6.7 %)	14 (93.7 %)	2 (13.3 %)	13 (86.7 %)	.37	.543 (NS)

Fig. 12 Comparison between Group A and Group B in terms of implant failure

that a geometrically closed quadrangular plate secured with bone screws creates stability in three dimensions [6]. The stability is gained over a defined surface area and is achieved by its configuration and not by thickness or length. The large free areas between the plate arms and minimal dissection permit good blood supply to the bone [10]. In the present study the newly introduced 3D plating system provides definite advantages over conventional 2D miniplates. Because of the torsional forces generated during function, two conventional miniplates are required to maintain predictable rigid fixation during healing. However the 3D plating system uses fewer plates and screws as compared to conventional miniplates to stabilize the bone fragments as only one 3D plate is necessary. Because of the easy bending of 3D plates they can be adapted better to the curvaceous, irregular bony architecture of this area. Thus it uses lesser foreign material, reduces the operation time and overall cost of the treatment [7, 10, 17]. 3D plating system

is an easy to use alternative to conventional 2 D miniplates to treat mandibular angle fractures [7]. The intraoral approach is preferred unless indicated otherwise as it is time saving and less traumatic [15].

One patient (6.7 %) in each Group had post-operative occlusion derangement. Patient in group A had slightly extruded mandibular central incisor which was loose with wire and was interfering with complete closure. It was corrected with retightening of arch bar and little incisal reduction. Patient in group B, occlusal derangement was managed with minor selective occlusal adjustment. Goyal et al. [16] reported occlusal derangement in 2 out of 30 patients (6.6 %), which was managed by selective occlusal adjustment. One patient (6.7 %) in each Group had post-operative infection at incision site at 1st week of follow-up owing to the poor oral hygiene. These same patients who had soft tissue infection, also had a slight mobility at the fracture site. This might be due to poor oral hygiene. The patients were conservatively managed by retaining the lower arch bar in position up to 6 weeks and were advised to be on soft diet. The patients were also motivated to maintain a good oral hygiene and consequently, the infection subsided at the next follow-up with the use of antibiotics. Infection rate in the present study was found to be within the result of the previous clinical studies by Feledy et al. i.e. 9 % (2 out of 22) [12], Guimond et al. i.e. 5.4 % (2 out of 37) [13] and Jain et al. [14] i.e. 10 % (2 out of 20). One patient (6.7 %) in Group A and two patients (13.3 %) in Group B reported with paresthesia of lower lip and chin region at all the follow-ups. Out of them, both the patient in Group B had pre-operative paresthesia, possibly due to

compression of the nerve by the fracture segments. Paresis in group A might be due to traction of mental nerve during the manipulation of the fracture segment. This agrees with another study on 3D plates by Guimond et al. [13] (8.1 %) who found that the main cause of sensory deficit in mandibular angle fractures was the trauma itself. In terms of implant failure, both three-dimensional and two-dimensional miniplates were equally efficient and none of the patients had implant failure at all the follow-ups. This is in accordance with the previous studies by Feledy et al. [12] and Guimond et al. [13] and Vineeth K et al. [18].

Conclusion

There was statistically no significant difference between 3D miniplate and 2D miniplate osteosynthesis in ORIF of mandibular parasymphysis fractures. Clinically, three-dimensional miniplates were found to be better than two-dimensional miniplates in terms of cost, ease of surgery, lesser implant material and operative time. However, 3D miniplates were unfavorable for cases where fracture line was oblique and in close proximity to the mental foramen, where they were difficult to adapt and there were more chances for tooth-root damage and inadvertent traction of the mental nerve. Owing to fewer numbers of cases in the present study, the superiority of three-dimensional miniplate could not be established statistically. Therefore clinical studies with larger sample size and different fracture sites are recommended.

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Ethical standard This study was approved by communication of decision of institutional ethics committee (IEC)/institutional review board (IRB), Government Dental College and Hospital Kottayam, Kerala India.

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