

2 mm Conventional Miniplates with Three-Dimensional Strut Plate in Mandibular Fractures

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Abstract

Aim: The aim of this study was to compare 2 mm conventional miniplates with three-dimensional (3D) strut plates in the treatment of mandibular fractures treated in the Department of Oral and Maxillofacial Surgery of a college in India, during 2012–2015. **Materials and Methods:** All 20 patients with mandible fracture requiring open reduction and internal fixation of the fracture were reported and reviewed in the Department of Oral and Maxillofacial Surgery of the same dental college in India, during 2012–2015. We classified the data according to the gender, age, etiology, fracture site, and method of treatment of the fractures. Fixation done in 10 patients with 2 mm conventional miniplates kept in Group I, while 10 patients with 3D strut miniplate system considered in Group II. **Results:** Assessment of patient was done under the following parameters with follow-up at regular intervals at 2nd day postoperatively and at 1st, 3rd, and 6th weeks postoperatively: pain, swelling, infection, interincisal mouth opening in millimeters, paresthesia/anesthesia, mobility between fracture fragments, overall occlusion, need for any supplemental fixation, fate of implant, and complications. **Conclusions:** 3D titanium miniplates showed similar results when compared to standard titanium miniplates with advantages such as reduction in operative time, ease of placement, and cost-effective over the conventional plate system.

Keywords: Biocompatibility, maxillofacial trauma, osteosynthesis, rigid and semi-rigid fixation, three-dimensional titanium miniplates

INTRODUCTION

Over the years, the methods to treat mandibular fractures have undergone many refinements. Newer methods have been tried and older ones have had improvements. Two approaches to mandibular fracture fixation have evolved: one is rigid stabilization, proposed by Spiessl,^[1] and the other one is semi-rigid fixation, proposed by Champy *et al.*^[2,3] Both the techniques have disadvantages, as the adaptation of the plate to the bone is difficult and time-consuming with rigid fixation, while fracture stability cannot be guaranteed with semi-rigid stabilization.^[4] A three-dimensional (3D) plate may overcome these shortcomings.

Farmand and Dupoirieux^[5] developed the concept of 3D miniplates whose shape is based on the principle of the quadrangle as a geometrically stable configuration for support. The basic form is quadrangular with 2 × 2 hole square plate and 3 × 2 or 4 × 2 hole rectangular plate. The plates are adapted to the bone according to the Champy's principles.

3D miniplate gives 3D stability to the fractured segments during healing. Locking system does not allow screw loosening and alteration in bone alignment or occlusal discrepancies on screw tightening. 3D locking plates have been designed with the hypothesis that this will overcome the disadvantages of both the systems, and also, advantages of both the systems will be combined for the management of mandibular fractures.

3D miniplate is formed by joining two miniplates with interconnecting vertical crossbars. The fundamental idea of

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the 3D bone plate is based on the principle of a quadrangular as a geometrically stable configuration for support. Increased stability is achieved by the geometric shape of the quadrangular plate rather than by its thickness or lengths.^[6-8] In the quest of an ideal implant material, maximum research has been directed toward titanium in the current century. Titanium is considered to be the most biocompatible alloplastic material. The biocompatibility stability and clinical experiences of titanium 3D miniplates have been well described recently by Faramnd and Wittenberg *et al.*^[6,7] The introduction of 3D strut plate/screw system has certain theoretical advantages over conventional plates and screws such as greater stability across fracture site, smaller incision, and lesser hardware requirement.

MATERIALS AND METHODS

Source of data

All 20 patients with mandible fracture requiring open reduction and internal fixation of the fracture were reported and reviewed in the Department of Oral and Maxillofacial Surgery of a dental college in India, during 2012–2015.

Inclusion criteria

Noncomminuted mandibular fractures requiring open reduction and internal fixation were included in the study.

A maximum number of surgeries were performed via an intraoral approach. Cases having preexisting scars were performed via extraoral/transbuccal approach.

Exclusion criteria

Patients having systemic diseases where general anesthesia is contraindicated with a history of uncontrolled diabetes mellitus, prolonged steroid therapy, compromised immunity, and associated pathology at or near fracture site and with a history of previous mandibular fracture or osteotomies were excluded from the study.

The patients were randomly categorized into two groups irrespective of age, sex, caste, and socioeconomic status.

- Group 1: having 10 patients where fracture fixation was done with 2 mm conventional or standard miniplate system [Figure 1]
- Group 2: having 10 patients where fracture fixation was done 2 mm 3D strut plate systems [Figure 2].

Thorough clinical, radiological, and laboratory evaluation of the patient was done to identify any criteria which would exclude the patients from the study; in addition, fitness of the patients to undergo the procedure was done.

Postoperative care

Postoperatively, intravenous (IV) antibiotics were used injection ceftriaxone 1 g 12 hourly combined with metrogyl 100 ml 8 hourly. The antibiotics were continued for 5 days postoperatively. If any subsequent infection occurred, the antibiotics were changed according to the culture and sensitivity reports. The patients were put on dexamethasone 8 mg 8 hourly IV postoperatively, and the dosage tapered down

in subsequent 3–4 days to decrease edema and inflammation in the surgical site. However, arch bars, if placed, were retained for 2–3 weeks without intermaxillary fixation. A radiograph was taken postoperatively to check the adequacy of reduction and fixation. After discharge, the patients were recalled on the 1st week, 3rd week, 3rd month, and 6th month. On each appointment apart from routine examination and wound care, the patients' maximal mouth opening, occurrences of any complication were assessed.

Postoperative assessment

The assessment of patients was done under the following parameters with follow-up at regular intervals of 2nd day postoperatively and at 1st, 3rd, and 6th weeks postoperatively: pain, swelling, infection, interincisal mouth opening in millimeters, paresthesia/anesthesia, mobility between fracture fragments, overall occlusion, need for any supplemental fixation, the fate of implant, and complications.

The statistical analysis was done using the Statistical Package for the Social Sciences version 15.0 statistical analysis software Arun Statistics, Lucknow (UP) India. The values were represented in number (%) and mean \pm standard deviation (SD). The following statistical formulas were used:

1. Mean: To obtain the mean, the individual observations were first added together and then divided by the number of observations. The operation of adding together or summation is denoted by the sign Σ .

The individual observation is denoted by the sign X , number of observation denoted by n , and the mean by \bar{X} .

$$\bar{X} = \frac{\Sigma X}{\text{No. of observations } (n)}$$

2. SD: It is denoted by the Greek letter σ . If a sample is more than 30, then

$$\sigma = \sqrt{\frac{\Sigma (X - \bar{X})^2}{n}}$$

When sampling in <30 , then

$$\sigma = \sqrt{\frac{\Sigma (X - \bar{X})^2}{n-1}}$$

3. Chi-square test:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

Where O = observed frequency,

E = Expected frequency

4. Student's t -test: To test the significance of two means, the Student's t -test was used

$$t = \frac{\bar{X}_1 - \bar{X}_2}{S \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

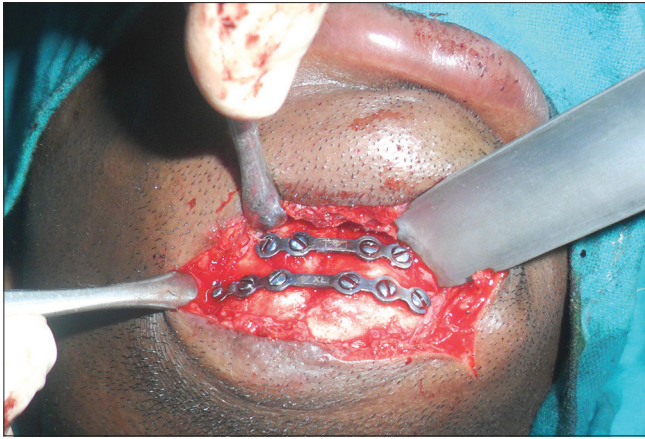


Figure 1: Fixation with 2 mm conventional or standard miniplate system

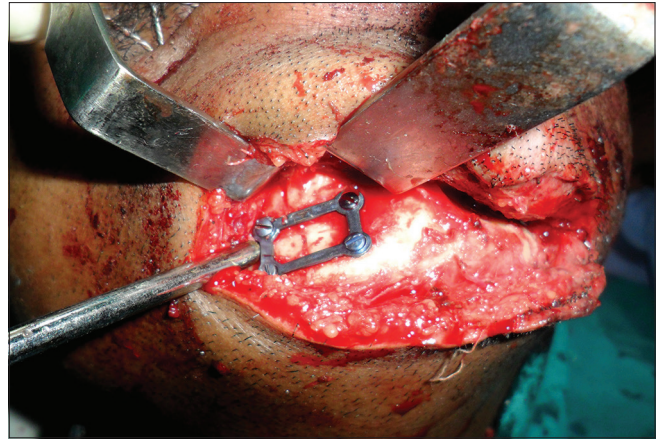


Figure 2: Fixation with 2 mm three-dimensional strut plate system

$$\text{Where } S^2 = \frac{(N_1 - 1)SD_1^2 + (N_2 - 1)SD_2^2}{N_1 + N_2 - 2}$$

Where \bar{X}_1, \bar{X}_2 are means of Group 1 and Group 2
 N_1 and N_2 are the number of observations in Group 1 and Group 2 respectively.
 SD_1 and SD_2 are standard deviations in Group 1 and Group 2, respectively.

- The Wilcoxon signed-rank statistic $W+$ is computed by ordering the absolute values $|Z1|, |Zn|$, the rank of each ordered $|Zi|$ is given a rank of Ri . Denote Where i is an indicator function. The Wilcoxon signed-rank statistic $W+$ is defined as

$$W_+ = \sum_{i=1}^n \phi_i R_i$$

$$Z = \frac{(W - \mu_w) \pm 5}{\sigma_w}$$

$$\sigma_w = \sqrt{\frac{[N(N+1)(2N+1)]}{6}}$$

- Level of significance: “ P ” is the level of significance
 $P > 0.05$: Not significant
 $P < 0.05$: Significant
 $P < 0.01$: Highly significant
 $P < 0.001$: Very highly significant.

RESULTS

The patients underwent thorough clinical examination and radiological examination followed by management, followed by the assessment of patients with follow-up at regular intervals of 2nd day postoperatively and at 1st, 3rd, and 6th weeks postoperatively. The results of the present study were as followed.

No statistically gender difference was found.

The range of operative procedure in Group I was 1.5 and 2 h, while that in Group II, it was 1 and 1.5 h. The

mean duration of the operative procedure in Group II (1.20 ± 0.26 h) was significantly lower than that of Group I (1.43 ± 0.34 h).

All the procedures performed on patients of Group I were found difficult in comparison of Group II by the surgeons. The difference in ease of procedure was found to be statistically significant ($P < 0.001$).

The minimum time for placement of miniplates in Group I was 15 min and the maximum time was 19 min, while in Group II, the minimum time for placement of miniplates was 5 min and the maximum time was 10 min. Time for placement of miniplates in Group II (7.20 ± 1.81 min) was found to be significantly lower than that of Group I (16.70 ± 1.25 min) [Table 1].

In both, the groups’ reduction in mouth opening ranged between 1 mm and 3 mm. Despite being the same range of reduction in mouth opening, reduction in mouth opening was significantly lower in Group II (1.40 ± 0.70) as compared to Group I (1.75 ± 0.72) and the difference in reduction in mouth opening of both the groups was found to be statistically significant ($P = 0.024$).

At follow-up at 2 days postoperatively, moderate swelling was found on all the patients of Group I (100.0%), While 30% of the patients in group II was having moderate swelling and rest 70% with mild swelling. The difference in swelling in both the groups was found to be statistically significant ($P < 0.001$). At follow-up at 1 week, moderate swelling was found in a higher proportion of patients of Group I ($n = 4$; 40.0%) as compared to Group II ($n = 2$; 20.0%), but this difference was not found to be statistically significant ($P = 0.329$) [Table 2].

After 1 week of postoperative follow-up, no mobility, infection, paresthesia, or failure was seen in any of the group. In our study, no radiographic evidence of plate fracture was noted in patients in Group 1 or Group 2 in follow-up period postoperatively. Occlusion was arranged, and no change in the union between different follow-up periods was found.

DISCUSSION

Experiments conducted by Champy *et al.* to validate mandibular osteosynthesis according to the Michelet’s principle affirmed that the mandibular cortex is strong enough to induce strains resulting from screws. Champy advised the use of two miniplates in the anterior region, one at the inferior border and second 5 mm above the lower plate. Miniplates were placed within 10 mm of the superior border, but in the anterior part of the mandible in front of the premolar, torsional movements were greater and higher when they were near the mandibular symphysis.^[9-11]

Internal fixation using miniplates and screws in maxillofacial surgery is regarded as the “gold standard.” The main functional advantages of miniplates are improved jaw function (in terms of mouth opening and bite force), patient comfort, improved speech, and oral hygiene and enhanced social interaction.^[12-14]

The 3D titanium plating system for mandibular fracture treatment is relatively new and was introduced by Farmand in 1992. The 3D miniplates consist of one 4 hole miniplates or two 4 hole miniplates joined by three or four interconnecting cross struts. 3D plates are positioned parallel to the fracture line. The connecting arms of the plate should be positioned rectangular to the fracture line. The main cause for mandibular fracture in our study was road traffic accidents, which also in accordance with the literature Gabrielli and Marcantons (2003), Bonmann *et al.* (2009), and Berg and Heymans (2012).^[15-17] This is probably due to the growing number of automobiles

on the road and rash high-speed driving with inadequate enforcement of traffic safety rules.

In our study, age of presentation ranged from 15 to 45 in Group 1 with a mean age of 27 years and 25–60 years in Group 2 with a mean age of 36 years, which is similar to that reported in the literature by Gabrielli and Marcantons (2003) and Bonmann *et al.* (2009).^[15,16] This could be explained due to more active lifestyle of this age group with increasing age more involvement in physical activities, fast and rash driving, interpersonal violence, alcohol abuse, and contact sports, while the people beyond 40 years are less affected by the incidence of fracture as they lead more calm, peaceful, and disciplined life.

A male predominance was noted in our study, the percentage of males with mandibular fracture was 95% and that of female was 5% which is similar to that reported in the literature by Gabrielli and Marcantons (2003) and Bonmann *et al.* (2009).^[15,16] This is probably due to higher levels of physical activity among men and more socially active life led by this group of individuals.

3D plate requires less surgical exposure and less time for placement, which might explain why operative procedures performed in Group 2 was easier as compared to Group 1 in our study. This is well supported by Sehgal *et al.* (2014) and Gandi and Kattimani (2012).^[18,19]

Less operating time was found in Group 2 when compared to Group 1. The range of operative time procedure in Group 1 was 1.5–2 h, while that in Group 2, it was 1–1.5 h. This is due to less time required in the placement of plates in Group 2 as compared to Group 1. In Group 2, the time of placement of plate ranges from 5 to 10 min, and in Group 1, it ranges from 15 to 19 min which also in accordance with the literature Guimond *et al.* (2005) and Babu *et al.* (2007).^[20,21] In Group 1, conventional miniplates required a longer time because these are linear plates and two plates are required for fixation at the parasymphysis or symphysis region. On the other hand, in Group 2, 3D plate is a geometric plate which consists of

Table 1: Between-group comparison of time of placement of graft (min)

Group	n	Mean	SD	Minimum	Maximum
Group I	10	16.70	1.25	15	19
Group II	10	7.20	1.81	5	10
Total	20	11.95	5.10	5	19

t=13.633; P<0.001. SD: Standard deviation

Table 2: Between-group comparison of postoperative pain at different time intervals

Follow-up	Total	Group I (n=310), n (%)	Group II (n=10), n (%)	Statistical significance (χ ² , P)
2 days postoperative				
Mild	7	0	7 (70.0)	10.769; <0.001
Moderate	13	10 (100.0)	3 (30.0)	
1 week postoperative				
Mild*	14	6 (60.0)	8 (80.0)	0.952, 0.329
Moderate	6	4 (40.0)	2 (20.0)	
3 weeks postoperative				
Mild*	18	9 (90.0)	10 (100.0)	1.053, 0.305
Moderate*	1	1 (10.0)	0	
6 weeks postoperative				
Mild*	20	10 (100.0)	10 (100.0)	0.000, 1.000
Moderate	0	0	0	

*Mild/no swelling

two horizontal bars interconnected with two vertical bars. Hence, single 3D plate stabilized the fracture at both the superior and inferior borders at a time; hence, time is saved in plate fixation.

Moderate swelling was observed on 2nd postoperative day in Group 1, whereas mild swelling was observed in Group 2. This could be due to smaller incision, less soft tissue dissection, and less time required for adaptation of 3D plate in case of Group 2. Swelling became reduced and disappeared subsequently on postoperative follow-ups, which also in accordance with literature by Khalifa *et al.* (2012) and Gandi and Kattimani (2012).^[18,19]

No patients in Group 1 or Group 2 developed postoperative pain in our study. Reduction in mouth opening after the procedure was lower in Group 2 with a mean of 1.40 as compared to Group 1 with a mean of 1.75. This is due to less time consumption and less surgical exposure required during the operative procedure in Group 2 as compared to Group 1.

No patients in Group 1 or Group 2 developed infection, paresthesia, mobility between fragments, or any other complications similar to the literature by Sehgal S *et al* 2014 Ebenezer and Ramalingam (2011), and Gandi and Kattimani (2012).^[18,19,21,22] This concurs with the findings of Guimond *et al.* (2005) where 5.4% infection rate was observed,^[20] Gabrielli and Marcantons (2003) reported 10%–15% infection rate mostly in the angle region,^[15] and Berg and Heymans 2012 reported infected osteosynthesis material in five patients.^[22]

In our study, occlusion was arranged in both the groups which also in accordance with Guimond *et al.* (2005) and Sehgal *et al.*^[19,20] This concurs with the findings of Khalifa *et al.* (2012) where two patients in each group had slight occlusal discrepancy which was successfully corrected by simple selective coronoplasty in two patients and guiding elastics in two cases.^[23]

No radiographic place fracture evidence was noted in both the groups in a postoperative follow-up. This is in accordance with the results reported in the literature by Berg and Heymans (2012).^[17]

Cases of oblique fracture or the fracture running through the mental foramina required more time in the placement of 3D plate. This might be due to difficulty in achieving principles of 3D plate fixation (horizontal bar perpendicular and vertical bar parallel to fracture line) which results in limitation in using 3D plate in such cases. In such cases, the plate was placed either inferior or superior to the foramina, and care has been taken while placing the plate superior to the foramina so that the screws are placed between the roots of the teeth. Another limitation of 3D plate was excessive implant material resulting from extra vertical bars incorporated for countering the torque forces which is in agreement with Babu *et al.* and Wittenberg *et al.*'s studies.^[7,21] In our study, no such cases were reported where 3D plate was placed near the area of the mental foramina.

The quadrangle geometry of the 3D plate assures a 3D stability of fracture sites as it offers good resistance against torque forces. A 2 mm 3D titanium miniplate provides sufficient inter-fragmentary stability with relatively low complication rates and decreased risk of plate fracture and subsequent infection when compared with a single 2 mm standard miniplate.

CONCLUSION

Based on the finding of our study, the following conclusions were derived:

1. Patients in the 27–37 years of age were the predominant age group presenting with a mandibular fracture
2. The most common cause of mandible fracture was found to be road traffic accidents with male predominance
3. Because of the closed quadrangular geometric shape, a single 3D plate stabilized the fracture both at the superior and inferior borders at a time; hence, there was a reduction in operative time
4. With the 3D titanium miniplate osteosynthesis technique, less surgical exposure of the underlying fracture site is needed, consequently less traction of the surrounding soft tissue leads to a more comfortable postoperative period
5. The implant was able to counteract forces along the fracture site, thus precluding hardware failure
6. Use of 3D miniplates is cost-effective in comparison to conventional miniplates as less number of plates and screws were needed.

We concluded that the 3D titanium miniplates showed similar results when compared to standard titanium miniplates with advantages such as reduction in operative time, ease of placement, and cost-effective over the conventional plate system.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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