

New design titanium miniplate versus conventional miniplate in treatment of mandibular angle fractures: A comparative study

ABSTRACT

Introduction: Mandibular angle fracture (MAF) is the second most common site of all fractures of the mandible with the highest complication rate. Management of MAF has evolved in the past four decades. The purpose of the prospective study was to compare the efficacy of new design titanium miniplate (NDM) with conventional titanium miniplate (CTM) in the treatment of MAF.

Objectives: Mouth opening, occlusion, bite force measurement, and radiographs compared preoperatively and first week, first month and third month postoperatively.

Materials and Method: Fourteen patients diagnosed with MAF were randomly divided into two groups: Group A (seven patients) was treated with NDM and Group B (seven patients) with CTM. Patients were assessed preoperatively and postoperatively at an interval of one week, one month and three months.

Results: Repeated measures ANOVA and Post hoc Tukey test showed a significant increase in bite force and mouth opening for both groups in first and third postoperative months. Unpaired *t*-test showed slightly better mouth opening in Group B and slightly higher bite force in Group A.

Discussion: Both miniplates fulfilled all the study objectives and equally satisfactory healing was seen at the end of third month. NDM offers better stability, rigidity, and anatomic reduction of the fracture with a drawback of difficulty in adaptation and increased operative timing compared to CTM. Hence, we would like to conclude that both miniplates are equally efficient in the treatment of non-comminuted angle fractures with the NDM having upper hand in stability.

Keywords: Bite force, internal fixation, mandibular angle fractures, new design miniplate, open fracture reduction, osteosynthesis

INTRODUCTION

Mandibular angle is formed at the junction of the ramus and the corpus of mandible, and the bone here is weak due to brusque change in direction between corpus and ramus in vertical plane (about 20°) and horizontal plane (about 70°), the presence of unerupted third molar, insertion of masseter and medial pterygoid muscle providing strength to ascending ramus, and the presence of high gonial angle.^[1-5] Attachment of elevator muscles plays an important role in displacement of fragments of fracture and allows generation of significant bite force, that is, 300–400 N.^[6]

Mandibular angle fracture (MAF) is the second most common site in all fractures of mandible, first being condyle, and

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most common isolated fracture site with an incidence of 23%–42% of all maxillofacial fractures and 12%–30% of mandible fractures.^[7-9] When multiple fractures occur, it is usually associated with fracture of opposite parasymphysis/body where left side is more common.^[10] The major cause of such fractures is interpersonal assaults and motor vehicle accidents. Other causes include falls, sports or industrial accidents, ballistic wounds, iatrogenic and jaw pathology.^[11,12] It is more common in the young male population in their third decade of life and is often associated with alcohol consumption. Angle fractures are broadly classified into favorable and unfavorable.^[13]

There are mainly two treatment modalities for treatment of mandibular fractures – closed reduction with maxillomandibular fixation (MMF) and open reduction and internal fixation (ORIF). ORIF is the treatment of choice nowadays. The concept of rigid fixation originated in 1932 in the orthopedic literature by Key. Luhr, Spiessl, and others derived inspiration from orthopedic biomechanical studies which stated accelerated bone healing through compression. (H) In 1976, Champy and colleagues investigated “miniplate” system and determined the “ideal lines of osteosynthesis” in the mandible which provides guidelines and locations for the most stable fixation of bone plates. For MAF, the most effective plate location was found to be along the superior border of the mandible.^[6,14,15] Edward Ellis and Lee Walker treated 81 patients with single non-compression miniplate and concluded that it is a simple and reliable technique with relatively minimal complications.^[16]

In 2014, B.T. Suer *et al.*^[17] introduced a new design titanium miniplates (NDM) [Figure 1]. The plate has one straight section and two lateral extensions. The straight section of the plate is four holed and is adapted to superior oblique ridge, and two

lateral extensions are with one hole each of which is bent and adapted the to buccal cortex of the ascending ramus. An *in vitro* study was conducted using NDM in dry hemimandibles of sheep. Findings demonstrated that NDM offers more resistance and stability to the lateral displacing forces at the fracture site compared to conventional miniplate [Figure 2]. Based on this study, background hypothesis of the present study derived that NDM offers better stability compared to conventional miniplates.

The aim of the present *in vivo* study was to determine the efficacy of NDM in patients with MAF using different parameters preoperatively and postoperatively.

MATERIALS AND METHODS

The prospective and comparative study was conducted on 14 adult male patients who reported to the Department of Oral and Maxillofacial Surgery from October 2017 to July 2019 and were diagnosed with MAF. Ethical Clearance was obtained from Institutional Ethical Committee with Reference number BVDUMC&H/2017-18/261 dated 09/01/2018.

Adult, dentate patients aged between 18 and 50 years requiring ORIF of MAF were included in the study.

EXCLUSION CRITERIA:

1. Medically compromised patients.
2. Edentulous and pediatric patients.
3. Comminuted fractures of mandibular angle.
4. Patients refusing follow-up.

Patients enrolled in the study were randomly divided into two groups:

Group A – Seven Patients treated with new design titanium miniplates.



Figure 1: New design titanium miniplate available in pairs for right and left side

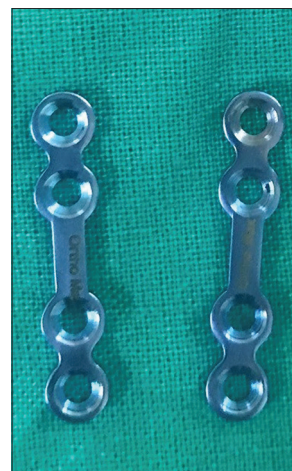


Figure 2: Conventional 2 mm four hole with gap titanium miniplate

Group B – Seven Patients treated with conventional titanium miniplates.

The result of Group A was compared with the results of Group B.

Following Parameters were included in the study:

- 1) Interincisal mouth opening measured with digital Vernier caliper to assess maximum mouth opening.
- 2) Occlusion – molar relation was recorded and categorized as satisfactory or deranged.
- 3) Radiographs – Orthopantomogram (OPG) and three dimensional computed tomography (3D CT) face for diagnosis preoperatively and to assess osteosynthesis postoperatively.
- 4) Bite force recorded in Newton (N) using digital bite force device.

All parameters were compared preoperatively and first week, first month and third month, postoperatively.

All patients in the study had undergone preoperative evaluation which included complete case history, routine blood investigation, chest X-ray, electrocardiogram, and OPG/3D CT face. Patients were also evaluated for other preoperative parameters. Arch bars were placed preoperatively in cases with displaced parasymphysis or body fracture. After preoperative work-up including informed consent for general anesthesia and using NDM/CTM, patients were posted for surgery.

Patients in both the group were operated by single surgeon with an experience of 9 years. Fractures were approached intraorally. Fracture site was exposed. IMF was done with the help of arch bar, IMF screws, or direct wiring assisting the reduction.

For Group A patients, a 2 mm six holes with gap NDM was used, the straight portion was bent and adapted along the external oblique ridge and two lateral extensions were adapted over the buccal cortex. The four holes on straight portion and short arm on distal fragment were fixed with 2 × 8 mm titanium screws. For fixation of long arm on proximal fragment 0.5 mm incision was placed extraorally and transbuccal trocar and cannula were placed and fixation was done with 2 × 8 mm screws [Figure 3].

For Group B patients, a 2 mm four holes with gap conventional miniplate was adapted on the superior border or with Champhy's method and secured with 2 × 8 mm titanium screw. Adaptation of NDM was slightly difficult and

time consuming as compared to conventional miniplate but intraoperative stability was superior.

Closure was done with 3–0 vicryl for intraoral site and 4–0 ethylone for extraoral site, followed by pressure dressing. Antibiotics and IV fluids were continued and the patient was discharged on the third postoperative day.

Postoperatively, both groups were assessed for all parameters at intervals of first week, first month and third month.

Statistical analysis

Statistical analysis was carried out using repeated measures ANOVA, post hoc Tukey test, and unpaired *t*-test to compare interincisal distance and bite force in both groups.

Repeated measures ANOVA and post hoc Tukey test showed a significant increase in bite force and mouth opening for both groups in the first and third postoperative months.

Unpaired *t*-test showed slightly better mouth opening in Group B which could be due to less periosteal stripping and slightly higher bite force in Group A which suggests better stability of NDM [Tables 1, 2 and Graphs 1 and 2].

Table 1: Comparison of two groups with respect to interincisal distance measured (IID) preoperatively (IID PO) and 1st week (IID 1), 1st month (IID 2) and 3rd month (IID 3) postoperatively using unpaired *t* test

IID	Group A	Group B	<i>t</i>	<i>P</i>
IID PO	13.82±6.15	22.34±3.77	3.02	0.02*
IID 1	18.81±4.23	23.43±5.36	2.45	0.04*
IID 2	28.35±5.68	31.33±5.12	1.56	0.16
IID 3	32.32±5.18	35.99±5.32	1.16	0.28

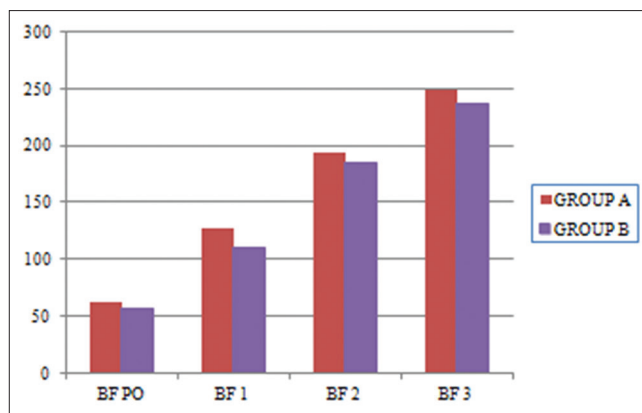
P-value <0.05 is considered as statistically significant



Figure 3: Fixation done using new design titanium miniplate



Graph 1: Graph shows interincisal distance with mean difference in preoperative and post operative events shows higher value of in Group B



Graph 2: Graph shows Bite force measurements with mean difference in preoperative and post operative events shows higher value of in Group A.

Table 2: Comparison of two groups with respect to interincisal distance measured (IID) preoperatively (BF PO) and 1st week (BF 1), 1st month (BF 2) and 3rd month (BF 3) postoperatively using unpaired t test

BF	Group A	Group B	t	P
BF PO	63.42±17.73	56.57±19.91	0.71	0.50
BF 1	127.85±29.65	110.42±28.99	1.07	0.32
BF 2	193.57±36.85	184.14±53.58	0.41	0.69
BF 3	249.28±69.38	236.71±62.07	0.58	0.58

P<0.05 is considered statistically significant

RESULTS

Present study was conducted in 14 adult male patients diagnosed with MAF to determine the efficacy of NDM over conventional titanium miniplates in treatment and to compare various parameters like occlusion, mouth opening, radiographs, and bite force in both groups.

Etiology was RTA in ten patients, fall in two patients, and assault in two patients. Eight patients had fracture on right side, and six patients had fracture on left side. All patients presenting with displaced fractures were associated with reduced mouth opening and deranged occlusion.

Mouth opening and bite force was reduced preoperatively and first week which could be due to pain and edema. Gradual improvement was observed in both groups on second and third follow-up. It was inadequate in one patient of Group A at the end of third month.

Molar relation was recorded in all the cases for assessment of occlusion. In all the cases occlusion was affected preoperatively. Occlusion was mildly deranged in the first postoperative week in three patients of Group B. Patients were kept on IMF for the next two weeks. Occlusion was deranged in one patient of Group A at third month follow-up.

Preoperatively, diagnosis was confirmed with the help of OPG/3D CT face. Postoperatively, OPG was taken at all scheduled follow-ups. CT/OPG finding was recorded and combined with clinical findings and was accordingly graded. 1A – Fracture, 1B – Healing in progress, 1C – Adequate healing, 1D – No healing seen.

Six of the seven patients in both groups had satisfactory healing at the end of third month. One patient in study group had miniplate fracture and subsequent nonunion on third postoperative follow-up. Clinically occlusion was deranged, and granulation tissue was observed on surgical site suggestive of infection. Patient was advised plate removal and retreatment.

One patient in the control group showed overlapping of bony fragments on first month follow-up. Occlusion was satisfactory after two weeks of MMF. Re-reduction was advised. However, the patient was satisfied with the outcome. No further surgical intervention was done.

Coming to surgical point of view, fixation with new design titanium miniplate is more time consuming and tedious job when compared to conventional miniplate, as it is bulky and more amount of periosteal stripping is required on proximal aspect. Plate bending and adaptation is technique sensitive and fixation of long arm on proximal fragment requires transbuccal approach, which makes the procedure lengthy and also increases the risk of complications like injury to marginal branch of facial nerve.

Clinically and radiographically both miniplates have similar outcome except when fixation was done with NDM and the first week occlusion was satisfactory in all cases compared to conventional plate (four of seven cases) which required further IMF.

DISCUSSION

Mandibular angle region is the junction between ramus and body where elevator muscles attach. It bears high masticatory occlusal forces which mimics the vertical and lateral compressive forces. Thus there is greater need for fixation in order to maintain rigidity under functional loads. Luhr, Spiessl, and others got inspired from orthopedic biomechanical studies related to rigid fixation which stated faster bone healing through compression. In early 1970, Schmoker and Spiessl developed compression plating system for mandible fractures, fixed with eccentrically placed bicortical screws also known as AO technique. Studies have shown higher complication rate and it is currently not used.^[18,19] In 1978 Champhy *et al.*^[14] introduced the concept of “Ideal Line of Osteosynthesis” by studying photoelasticity of araldite models. The line extended from angle to symphysis where two plates are placed in symphysis region and one plate in angle region.

The stability of single miniplate on external oblique ridge has always been questioned. Biomechanical studies have shown less favorable behavior of single miniplate. Alkan *et al.*^[20] (2007) in their biomechanical study also stated that biplanar plate orientation provided greater biomechanical stability than the monoplanar and single miniplate. Levy *et al.*^[21] (1991) and Fox *et al.*^[22] (2003) reported lower complication rate in two miniplate system. Recently Rai *et al.*^[23] (2018) stated that two miniplates offer better stability in unfavorable fracture. Mondal *et al.*^[24] (2018) showed no significant advantage of two miniplates. Contradicting two miniplate system, Ellis and Walker (1996), Ellis^[25] (1999, 2010), and Siddiqui *et al.*^[26] (2006) in their studies concluded that using single miniplate for MAF is a more reliable technique with less complication.^[6,25,26] Ellis and Walker^[27] (1994), Ellis (1999), and Ferrari *et al.*^[28] (2018) reported higher complication rates with two miniplate system.^[6]

Currently various studies have been conducted comparing 3D plates with conventional miniplates. In a study conducted by Mathew *et al.* (2020) comparing 3D miniplate with single four hole miniplate in twelve patients diagnosed with unilateral MAF.^[29] Kaushik S *et al.*^[30] (2020) compared 3D plates with conventional miniplates in the treatment of mandibular fractures. 3D plates showed no statistically significant advantage over single miniplate; however, study parameters were better in 3D plate group in both studies with advantages such as less operating time, ease of application, and cost-effective over the conventional plate system.

The new design plate was introduced by B.T. Suer *et al.* in 2014. It is similar to conventional miniplate with two additional lateral extensions. The plates were specially designed for

fractures of angle region available in pairs of right and left side. The proximal arm is longer compared to distal arm resembling the height of mandible. Also the plate has biplanar orientation which offers better stability. Authors tested the new plate by performing biomechanical study on 30 hemimandibles of sheep using Champhy’s technique, testing for mechanical resistance to vertical, lateral, and tensile forces concluding that NDM offered better stability to lateral (torsional) forces when compared to conventional straight miniplate.^[17] Also it was more resistant to vertical. Authors further confirmed its stability in a 3D finite element study and concluded that NDM can be a useful alternative to other modalities in the treatment of noncomminuted and minimally displaced angle fractures and tensile forces when compared to conventional plates.^[31]

Thus, in light of biomechanical experiment we conducted a study to check the stability and rigidity of NDM in patients comparing the conventional four hole with gap straight miniplate.

In 2017, Saikrishna Degela *et al.*^[32] performed a similar study on 20 patients. The study showed mixed results. Anatomic reduction was better in NDM group and one case in conventional miniplate group had recurrent infection and went for plate removal. Authors also mentioned difficulty in plate adaptation and requirement of transbuccal approach.

In the present study anatomic reduction was achieved in all cases except in one case of control group.

Hardware fracture occurred in study group with subsequent non-union and infection. Fracture could be due to increased loading over bar which may have occurred because of poor adaptation or movement. Transbuccal approach has been used in the study as there was difficulty in fixing the lateral arm. The limitation of current study was lack of sample size, and thus we would like to propose a study with greater sample size.

CONCLUSION

The conclusion drawn from our study was: Both miniplates fulfilled all the study objectives and equally satisfactory healing was seen at the end of third month. NDM offers better stability, rigidity, and anatomic reduction of the fracture compared to conventional titanium miniplate in the treatment of angle fractures. It is difficult to manipulate and adapt new design titanium miniplate in comparison to conventional miniplate; also the NDM requires transbuccal approach and more periosteal stripping for fixation of the lateral extensions; thus, it is technique sensitive and requires surgical expertise. Hence we would like to conclude that both miniplates are equally efficient in the treatment of non-comminuted angle fractures with the NDM having the upper hand in stability.

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Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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