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Research Article

Comparison of Conventional Titanium Linear Miniplate versus 3d Rectangular Grid Plate for the Fixation of Mandibular Angle Fracture – A Prospective Clinical Study

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ABSTRACT

Background: Mandibular angle fractures are among the most common facial fractures and remain challenging because of unfavourable biomechanical forces and high complication rates. Conventional titanium linear miniplates are widely used; however, three-dimensional (3D) rectangular grid plates have been introduced to provide enhanced biomechanical stability and minimize postoperative complications.

Aim: To compare the clinical efficacy of conventional titanium linear miniplates and 3D rectangular grid plates in the management of mandibular angle fractures.

Materials and Methods: A prospective randomized clinical study was conducted on 20 patients aged 18–60 years with isolated mandibular angle fractures. Patients were equally allocated into two groups: Group I underwent open reduction and internal fixation (ORIF) using a conventional titanium linear miniplate (n=10), while Group II received fixation with a 3D rectangular grid plate (n=10). Clinical parameters including fracture stability, occlusion, operative time, mouth opening, postoperative pain, and swelling were evaluated at 1 week, 1 month, and 3 months postoperatively.

Results: Both groups achieved complete fracture stability, satisfactory occlusion, and uneventful fracture healing during the follow-up period. No statistically significant differences were observed between the groups with respect to fracture stability, occlusion, pain, or swelling. However, the 3D rectangular grid plate group demonstrated significantly shorter operative time and greater postoperative mouth opening at 3 months. No cases of plate fracture, screw loosening, malunion, or non-union were observed in either group.

Conclusion: Both the conventional titanium linear miniplate and the 3D rectangular grid plate provided effective and reliable fixation for mandibular angle fractures with comparable fracture stability and clinical outcomes. However, the 3D rectangular grid plate offered the advantages of significantly shorter operative time and improved postoperative mouth opening, making it an effective alternative for the management of mandibular angle fractures.

Keywords: Mandibular Angle Fracture, 3D Rectangular Grid Plate, Titanium Linear Miniplate, Open Reduction And Internal Fixation, Mouth Opening, Operative Time.

INTRODUCTION

Mandible is the largest, strongest, and lowest bone in the human face, has a complex role in both functional occlusion and facial aesthetics.[2] The mandible, which is a component of the temporomandibular joint, is the only moving

bone in the skull. Its structure is U-shaped, with segments that are both vertical and horizontal. The angle and ramus make up the vertical section, whilst the body, para-symphysis, and symphysis make up the horizontal segment.[1] The condyles of the temporomandibular joint (TMJ) allow the mandible to articulate with the skull. It is in dental occlusion with the maxilla and is joined to other facial bones by muscles and ligaments. Despite being a sturdy bone, the mandible has several weak spots that can break. The sub-condylar region, angle, distal body, and mental foramen are the most often fractured areas. Stress concentration and anatomical features like the mandibular canal make these places vulnerable.[1]

The phrase "mandibular angle fracture" describes a fracture line that runs inferiorly via the inferior border or posteriorly in the direction of the gonial angle, beginning where the anterior border of the mandibular ramus meets the mandibular body. The severity of the impact pressures, biomechanical traits such bone density, mass, and irregular anatomic shape, which may exhibit reduced resistance, the existence of an impacted third molar, and a high gonial angle are all contributing causes to mandibular angle fractures.[2]

Due to differing anatomical and biomechanical factors, the management of these fractures remains controversial despite improvements in internal fixing techniques. There is disagreement over the best course of treatment because Numerous methods of treatment have been assessed with varying complications. According to recent clinical and experimental studies, utilizing a solitary mono-cortical miniplate at the superior border was believed to be the standard treatment approach with few complications. However, several surgeons had concerns about stability because the inferior border splayed when loading forces were applied Farmand and Dupoirieux took these factors into mind when creating 3-D plates.[3]

There are numerous studies on the application of linear and curvilinear plates for fixing mandibular fractures, however there aren't many on the use of low -profile plates. mesh or strut plates in three dimensions (3D).[4] Farmand and Dupoirieux in 1992 announced the development of three-dimensional titanium plates and screws. The quadrilateral is a geometrically stable structure for support, which informs their shape. Compared to conventional miniplates and reconstruction plates, the geometric shape that creates a cuboid achieves 3D stability.[5] This three-dimensional miniplate is made up of two miniplates with four holes connected by three or four cross struts. The rectangular plate forms a cuboid that offers three-dimensional stability when combined with the screws that are mono-cortically fastened to the outer cortex. The 3-D plate's geometry allows for the addition of more screws, offering three-dimensional stability and resistance to torque forces while preserving its low profile and malleability. The use of 3-D plates, being small in size, requires a smaller incision, decreases the area of adaptation, use of less osteosynthesis material, less surgical time, and less bleeding and fewer complications.[6]

This study is a prospective clinical study to compare titanium linear miniplate versus 3D rectangular grid plate for the fixation of mandibular angle fracture in terms of fracture stability, occlusion, operative time, mouth opening, pain and swelling.

Aim

This prospective study is to compare the efficacy of titanium linear miniplate versus 3D rectangular grid plate for the treatment of mandible angle region.

Objectives

The objectives of this study are to compare the following parameters in relation to titanium single linear miniplate and 3D rectangular grid plate for the treatment of mandibular angle fracture:

1.Fracture stability 2 Occlusion 3 Operative time 4 Mouth opening 5 Pain and 6 Swelling

MATERIALS AND METHODS

This prospective study includes sample size of 20 individuals of both genders with the age group of 18-60 years; who came to the department of Oral and maxillofacial surgery Government Dental College and Hospital Kadapa, Andhra Pradesh for the treatment of mandible angle fracture. Each patient was thoroughly informed about the planned surgical procedure and written informed consent was given prior to participation.

Method of Collection of Data

Patients were randomly divided into two groups. A preoperative assessment, including evaluation of dental occlusion and radiographic analysis, was conducted for all participants. All 20 patients underwent open reduction and internal fixation (ORIF) using either a 3-D rectangular grid plate or conventional titanium miniplate, depending on their group assignment. Postoperative evaluation was conducted over a follow-up period of 3 months.

Parameters assessed included fracture stability, occlusion, operative time, post operative mouth opening, post operative pain and swelling.

Study Design

This clinical study included 20 patients (10 in each group) diagnosed with mandibular angle fracture, who were treated with open reduction and internal fixation between April 2023 and April 2026. Patients were randomly assigned to one of the two treatment groups. Relevant demographic details, preoperative findings, investigations, and postoperative complications were systematically recorded for all participants.

Criteria for Selection of the Subjects

Individuals involved in the study were diagnosed with angle fractures of mandible who required an open reduction and internal fixation with 2.00mm 3-D miniplate and 2.00mm linear miniplate.

Inclusion Criteria:

• Fracture in mandibular angle region
• Patients between 18-60 years of age.
• Patients with no systemic disease (ASAI & ASA II) • Surgical site free of active infection.

Exclusion Criteria:

• Medically compromised patients (ASA III &ASA IV).
• Patients with haematological disorders.
• Patients having active infection at the site of infection.

In this study individuals were randomly divided into two groups:

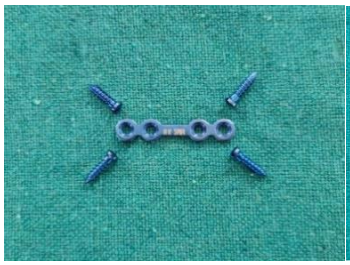

Figure 1- Conventional titanium miniplate

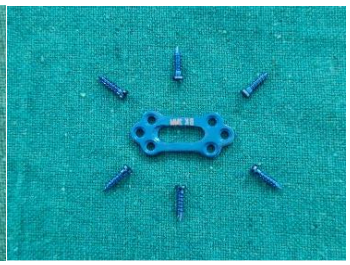

Figure 2- Rectangular 3D grid plate

SURGICAL TECHNIQUE

Depending on the clinical indication, either local anaesthesia or general anaesthesia was used during open reduction and internal fixation (ORIF) in both groups. 7.5% povidone-iodine (Betadine) was used to completely irrigate the oral cavity, and Betadine was used to prepare and drape the surgical field. For haemostasis and anaesthesia, local infiltration was administered using 2% lidocaine and 1:80,000 adrenaline. Depending on the preoperative evaluation, teeth on the fracture line were either removed or kept. To obtain the best possible occlusion, Erich arch bars were positioned before to surgery together with guiding elastics.

GROUP 1, Retraction of the lips was done, followed by a vestibular incision placed 5 mm below the mucogingival junction to adequately expose the fracture site. Standard layered dissection was performed through the mucosa and periosteum. In select cases, an extraoral approach was employed via a pre-existing laceration. Next, a mucoperiosteal flap was cautiously raised. Debris was removed from the fracture site in order to promote healing. After anatomical reduction of the bony pieces, intermaxillary fixation (IMF) was used to ensure appropriate occlusion. The fracture was stabilized by performing mono-cortical drilling and internal fixation with a single linear titanium miniplate with a 2 mm × 4 hole was fitted to the angle region's lateral cortical bone ventral to oblique ridge and secured in the upper border (tension zone) with 2 mm × 8 mm mono-cortical screws.

FIG-3 PREOPERATIVE OPG GROUP 1

FIG-4 POST OPERATIVE OPG GROUP 1

FIG-7 PRE OPERATIVE MOUTH OPENING GROUP 1

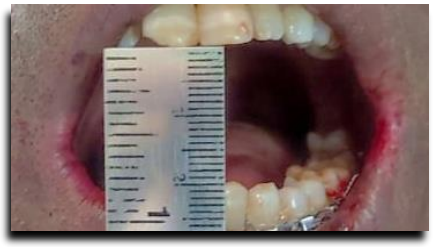

FIG-7 POST OPERATIVE MOUTH OPENING GROUP 1

FIG-7 EXPOSURCE OF FRACTURE SITE GROUP 1

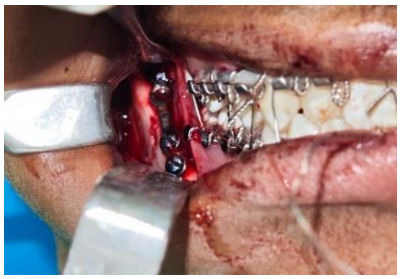

FIG-8 FIXATION WITH COVENTIONAL TITANIUM MINIPLATE GROUP 1

FIG-9 PRE OPERATIVE OPG GROUP 2

FIG-10 POST OPERATIVE OPG GROUP 2

FIG-11 PREOPERATIVE MOUTH OPENING GROUP 2

FIG-12 POST OPERATIVE MOUTH OPENING GROUP 2

FIG-13 EXPOSURE OF FRACTURE SITE GROUP 2

FIG-14 FIXATION WITH 3D RECTANGULAR GRID PLATE GROUP 2

GROUP 2: General anaesthesia was administered with nasotracheal Intubation. At the approximate location of the fracture, a skin crease is found about 2 cm below the mandibular inferior border, with sufficient extension on both sides to permit the implantation of the plate and the required retraction. After taking all aseptic precautions, the submandibular incision site was infiltrated with 2% lignocaine and adrenaline (1:80,000). The platysma, skin, and subcutaneous fat are removed, and the facial nerve's marginal mandibular branch is located and pulled back. The fracture site was visible as the dissection was continued to deeper planes. Occlusion was created and fracture segments were reduced and approximated. A single rectangular grid plate with a 2 mm x 6 hole was modified so that vertical bars were parallel to the fracture line and horizontal cross bars were perpendicular to it. The grid plate was fastened using 2 mm x 8 mm mono-cortical screws.

Every patient's occlusion was examined by releasing MMF. 3-0Vicryl for periosteum and muscle were used for closure. 3-0 prolene was used for subcuticular suturing to seal the skin. Patients were observed one week, one month, and three months after surge

Post-Operative Care: All patients were put on intravenous antibiotics for a duration of five days. Followed by 24 hours, the occlusion was checked for any derangement. Patient were instructed to consume soft diet for 4 weeks. Patients were recalled on intervals at 1 week, 4 week, 12 weeks

RESULTS

A total of 20 patients with mandibular angle fractures were included in the study and randomly allocated into two equal groups: Group I (titanium linear miniplate, n=10) and Group II (3D rectangular grid plate, n=10). Fracture stability and occlusion improved progressively in both groups throughout the follow-up period. At the first postoperative week, fracture stability scores were comparable between Group I (0.80 ± 0.42) and Group II (0.90 ± 0.32) (p=1.000). Complete fracture stability was achieved in all patients by one month and maintained at three months. Similarly, occlusal outcomes were comparable between the groups at all follow-up intervals (p>0.05), with all patients demonstrating satisfactory occlusion at three months.

The mean operative time was significantly shorter in Group II than in Group I (47.2 ± 5.49 vs. 62.0 ± 8.75 minutes; p<0.001). Mouth opening improved significantly over time in both groups (p<0.001). Although no significant difference was observed during the first week or first month, patients treated with the 3D rectangular grid plate demonstrated significantly greater mouth opening at three months (37.3 ± 2.83 mm vs. 34.6 ± 1.58 mm; p=0.018). Moreover, 90% of patients in Group II achieved a mouth opening of at least 35 mm compared with 50% in Group I (p=0.04), indicating superior functional recovery with the 3D rectangular grid plate.

Pain and swelling scores decreased progressively in both groups during the postoperative period. Intragroup analysis demonstrated significant reductions in pain over time in both groups (p<0.01), whereas swelling showed a significant reduction only in Group II (p=0.01). However, intergroup comparisons for pain and swelling at all postoperative intervals revealed no statistically significant differences (p>0.05). Overall, both fixation systems provided satisfactory clinical outcomes; however, the 3D rectangular grid plate offered significantly shorter operative time and better long-term mouth opening while maintaining fracture stability and occlusal outcomes comparable to those achieved with the conventional titanium miniplate.

Table 1. Summary of Intergroup Comparison

Parameter	Group I (Titanium Miniplate)	Group II (3D Rectangular Grid Plate)	p-value	Significance
Fracture stability (1 week)	0.80 ± 0.42	0.90 ± 0.32	1.000	NS
Occlusion (1 month)	0.80 ± 0.42	1.00 ± 0.00	0.153	NS
Operative time (min)	62.0 ± 8.75	47.2 ± 5.49	<0.001	Significant
Mouth opening (3 months, mm)	34.6 ± 1.58	37.3 ± 2.83	0.018	Significant

≥35 mm mouth opening	50%	90%	0.040	Significant

Table 2. Changes in Clinical Parameters over Time

Parameter	Group I	Group II	Intragroup p-value
Fracture stability	Improved to 100% by 1 month	Improved to 100% by 1 month	0.01 / 0.03
Occlusion	Improved to normal by 3 months	Improved to normal by 3 months	0.03 / 0.017
Mouth opening	28.1 → 33.0 → 34.6 mm	29.8 → 34.5 → 37.3 mm	<0.001 / <0.001
Pain	3.0 → 2.6 → 2.1	3.0 → 2.8 → 2.4	<0.001 / 0.006
Swelling	2.7 → 2.5 → 2.5	3.0 → 2.7 → 2.4	0.32 / 0.01

Table 3. Overall Study Findings

Outcome	Result
Sample size	20 patients (10 per group)
Fracture stability	Comparable between groups
Occlusion	Comparable between groups
Operative time	Significantly shorter with 3D rectangular grid plate
Mouth opening	Significantly better at 3 months with 3D rectangular grid plate
Pain	Reduced significantly in both groups
Swelling	Comparable between groups; significant reduction only within Group II
Overall conclusion	Both fixation methods were clinically effective; the 3D rectangular grid plate provided shorter operative time and superior functional recovery.

DISCUSSION

According to Farmand M et al (1992)[7]: The basic idea behind three-dimensional (3D) fixation is that a geometrically closed rectangular plate can be screwed to the bone to provide stability in all spatial planes. 3D plates offer stability over a specified surface area, in contrast to conventional methods that depend on the plate's thickness or length. According to Dr. Arindom Chang Mai et al (2021)[8] the mandible is subject to three main forces at any point along a fracture line: bending, torsional, and shear. Because 3D miniplates' vertical arms are oriented parallel to the fracture, they offer better resistance to torque forces, which makes them especially useful for reducing these stresses. According to Kanubaddy et al (2016)[3] and Sudheer et al (2019)[9], Better resistance to inferior border splaying, enhanced interfragmentary stability, fewer postoperative occlusal discrepancies, and a decreased incidence of infection were among the therapeutic benefits of rectangular grid plates.

In this study, we compared the use of Conventional Titanium Linear Miniplate with the 3D Rectangular Grid Plate system for the management of mandibular angle fractures. This prospective study includes sample size of 20 patients of both genders with the age group of 18-60 years; who reported to the department of Oral and maxillofacial surgery Govt. dental college and hospital Kadapa, Andhra Pradesh for the treatment of mandible angle fracture. Patients were randomly assigned into two groups and treated with open reduction and internal fixation via an intraoral buccal vestibular approach/extraoral submandibular approach. Each patient was thoroughly informed about the planned surgical procedure and provided written informed consent prior to participation.

In this study we have operated group 1, Patients titanium linear miniplate with intraoral approach and group 2, Patients 3D rectangular grid plate with Extraoral approach.

The clinical parameters evaluated in this study include: Fracture stability, Post Operative Occlusion, Operative time, Post Operative Mouth Opening, Post Operative pain and Post-operative Swelling.

The age of the patients in our study ranged from 25 years to 43 years in group 1 and 18 years to 37 years in group 2. RTAs accounted for fractures in 16 patients (80%), while assault was the cause in 4 patients (20%). Among the 20 patients ,14 patients (35%) had fractures on the left side of mandible and remaining 6

patients (65%) had fractures on the right side "of mandible.

Fracture stability - Fracture stability was assessed by digital palpation at 1 week, 1 month, and 3 months postoperatively. At 1 week, the mean stability score was 0.80 ± 0.42 in Group 1 and 0.90 ± 0.32 in Group 2, with no significant intergroup difference ($t = 0.62$, $p = 1.000$). By 1 and 3 months, all patients in both groups achieved complete fracture stability (mean = 1.00 ± 0.00). Intragroup analysis showed significant improvement over time in both groups (Group 1: $F = 6.00$, $p = 0.01$; Group 2: $F = 4.00$, $p = 0.03$). These findings indicate comparable fracture stability with both fixation systems and are consistent with the studies by Kanubaddy et al. (2016)[3] and Das et al. (2023)[10.]

Occlusion – Postoperative occlusion was assessed at the 1st week, 1st month, and 3rd month. Both groups showed comparable occlusal outcomes at the 1st week ($p = 1.000$) and 1st month ($p = 0.153$), with no statistically significant difference. By the 3rd month, all patients in both groups achieved satisfactory occlusion, and statistical comparison was not applicable as both groups had identical outcomes. Overall, no statistically significant difference in postoperative occlusion was observed at any follow-up interval ($p > 0.05$), indicating that both conventional titanium linear miniplates and 3D rectangular grid plates were equally effective in restoring occlusion. These findings are consistent with those reported by Kanubaddy et al. (2016)[3] and Das et al. (2023)[10.]

Operative time- Total time taken from starting of incision up to the time of fixation of Linear miniplate or rectangular grid plate. Measured with digital surgical clock. The mean operative time was significantly higher in Group 1 (62.0 ± 8.75 minutes) compared to Group 2 (47.2 ± 5.49 minutes). This difference was statistically highly significant ($t = 4.49$, $p < 0.001$), indicating improved surgical efficiency with the 3D rectangular grid plate system.

In our study, the conventional titanium linear miniplate required significantly more plate fixation time compared to the 3-dimensional rectangular grid plate, and this difference was statistically significant which is not consistent with Kanubaddy et al. (2016)[3] and Das et al. (2023)[10]

Post-operative mouth opening – Postoperative mouth opening was assessed at the 1st week, 1st month, and 3rd month. Both groups showed progressive improvement over time. Intergroup comparison revealed no statistically significant difference at the 1st week ($p = 0.34$) or 1st month ($p = 0.29$). However, at the 3rd month, Group 2 demonstrated significantly greater mouth opening than Group 1 ($p = 0.018$). Clinically, a mouth opening of ≥35 mm was achieved in 90% of patients in Group 2 compared with 50% in Group 1, which was also statistically significant ($p = 0.04$). These findings suggest superior postoperative functional recovery with the 3D rectangular grid plate and are consistent with the findings of Y.D. Dinesh et al. (2025)[11], but differ from those reported by Kanubaddy et al. (2016)[3] and Das et al. (2023)[10]

Post-operative pain- In case of linear miniplate versus rectangular grid with the help of ordinal scale on 1st week, 1st month and 3rd month postoperatively.

Pain scores decreased progressively in both groups:

- Group 1: 3.00 ± 0.00 → 2.60 ± 0.52 → 2.10 ± 0.57
- Group 2: 3.00 ± 0.00 → 2.80 ± 0.42 → 2.40 ± 0.52

Intergroup comparisons showed no significant difference at any time point (Day 3: $p = 0.35$; Day 5: $p = 0.23$),

According to Y.D. Dinesh et al (2025)[11], in post operative period pain was considerably reduced in 3D rectangular which is not in accordance with our present study and in Das et al. (2023)[10] they didn't find any statistically significant differences between two fixation systems so this is consistent with our current study.

Post-operative swelling- In case of linear miniplate versus rectangular grid with the help of ordinal scale on 1st week ,1st month and 3rd months postoperatively.

Swelling scores showed a decreasing trend:

- Group 1: 2.70 ± 0.48 → 2.50 ± 0.53 → 2.50 ± 0.53
- Group 2: 3.00 ± 0.00 → 2.70 ± 0.48 → 2.40 ± 0.52

The current study also showing no significant difference in post operative swelling in two groups, so Y.D. Dinesh et al (2025)[11] is consistent with our study.

CONCLUSION

The present study compared the clinical efficacy of conventional titanium linear miniplates and 3D rectangular grid plates for the fixation of mandibular angle fractures in 20 patients randomly divided into two groups. The parameters evaluated were fracture stability, postoperative occlusion, operative time, mouth

opening, pain, and swelling. The 3D rectangular grid plate demonstrated significantly greater postoperative mouth opening and required significantly less operative time than the conventional titanium linear miniplate. Although the 3D plate showed slightly better early fracture stability and faster resolution of postoperative pain and swelling, these differences were not statistically significant. Both groups achieved complete fracture stability by 4 weeks and stable occlusion by 12 weeks. Within the limitations of this study, the 3D rectangular grid plate can be considered an effective and reliable alternative to the conventional titanium linear miniplate for the management of mandibular angle fractures. However, further studies with larger sample sizes and longer follow-up are recommended to confirm these findings.

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