Original Article
DOI: https://doi.org/10.70749/ijbr.v3i7.2185

INDUS JOURNAL OF BIOSCIENCE RESEARCH
https://ijbr.com.pk
ISSN: 2960-2793/ 2960-2807

To Evaluate the Outcome of 3-D Titanium Plates versus Conventional Miniplates in the Management of Mandibular Angle Fracture in Abbasi Shaheed Hospital

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ARTICLE INFO

Keywords: 3-D Titanium Plates, Conventional Miniplates, Mandibular Angle Fracture, Surgical Management.

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Declaration
Authors' Contribution
All authors equally contributed to the study and approved the final manuscript

Conflict of Interest: No conflict of interest.

Funding: No funding received by the authors.

Article History
Received: 20-06-2025 Revised: 09-07-2025
Accepted: 10-07-2025 Published: 15-07-2025

ABSTRACT

Objective: To evaluate and compare the clinical outcomes of three-dimensional (3D) titanium plates versus conventional miniplates in the surgical management of mandibular angle fractures. **Methods:** This randomized controlled trial was conducted in the Department of Oral and Maxillofacial Surgery at Abbasi Shaheed Hospital, Karachi in the duration from 11th January, 2025 to 15th June, 2025. A total of 60 adult patients with closed unilateral mandibular angle fractures were randomly assigned into two groups: Group 1 (3D plates, n=30) and Group 2 (conventional miniplates, n=30). Outcome measures included operative time, pain scores, postoperative mouth opening, and infection rates. Surgeries were performed under general anesthesia by a single surgeon using a standardized approach. Data were analyzed using SPSS v23, with independent t-tests and Chi-square tests applied. **Results:** Group 1 had significantly shorter operative times (44.0 ± 1.4 min vs. 54.5 ± 1.7 min; $p < 0.001$) and lower pain scores on both postoperative day 1 and day 7 ($p < 0.001$). Mouth opening on day 7 was clinically adequate in both groups, though slightly higher in the conventional group. Infection occurred in 6.7% of 3D plate patients and 16.7% in the conventional group ($p = 0.42$). No reoperations or hardware failures were reported. **Conclusion:** 3D titanium plates provide efficient, stable fixation for mandibular angle fractures, with reduced operative time and postoperative discomfort. Their use is supported by both clinical performance and alignment with international evidence, making them a viable alternative to conventional miniplates in appropriate surgical settings.

INTRODUCTION

Mandibular angle fractures are among the most common facial fractures (1), with the percentage of approximately 20-25% of all facial fractures. A retrospective review published in 2007 showed that in patients with a facial fracture, mandibular fractures ranked second (23.3%) to nasal bone fractures (58.6%) (2). Among all the fractures of mandible, angle fractures account for 27%–30% because the cross-sectional area is relatively thin within the angle, and also because of the presence of the third molar tooth (3). These fractures often require surgical intervention to restore proper function and aesthetics thus creating a unique clinical challenge for reconstructive surgeons (4, 5). Traditionally, this has been achieved through the use of conventional miniplates, which offer adequate stability and fixation in many cases. Before the introduction of miniplates these fractures were treated by intraoperative maxillomandibular fixation (MMF) along with rigid internal fixation. However, recent advancements in technology have led to the development of 3D metal plates, which have been proposed to offer several potential advantages over their conventional counterparts. This miniplate osteosynthesis allows early exercise and has the advantage of using plates that are easy to adapt (6). Farmand et al. 1992 developed the concept of three-dimensional miniplates (7). In this plating system, the screws are arranged in the configuration of a box on both sides of the fracture which creates a broadband platform, increasing the resistance to twisting and bending of the plate and reducing the possibility of flaring at the inferior border of the fracture site (8). Use of 3D miniplates in the management of mandibular angle fractures decreases the postoperative complications by 62% in contradiction to the use of two miniplates (9).

A randomized control trial was done using two groups in which infection rate was less in 3D miniplate group than conventional group (10). In another trial, there was no statistical significant difference between the two groups regarding pain, maximum mouth opening, bite force or bone density (11). In another study, the mean duration of operation was significantly less with 3-D titanium plates

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compared to standard miniplate (15.79±1.49 min. Vs 17.69±1.28 min. respectively (12).

According to the literature search the data present on this topic is limited and varies from study to study, therefore the present study is designed to generate local data and to validate the findings of the previous studies by comparing the two modalities in the fixation of mandibular angle fracture. The better of the two will be utilized in future.

Objective

To compare the outcome of 3D titanium miniplate versus conventional plate in the management of mandibular angle fracture.

METHODOLOGY

This randomized control trial was conducted in Oral and maxillofacial surgery department at Abbasi Shaheed Hospital. The duration of study is from 11th January, 2025 to 15th June, 2025. A non-probability consecutive sampling technique was used to include study participants in the study. The sample size was calculated from Oepnepi calculator using mean±SD as parameter for sample calculation, with confidence interval 95% and power of the test 80%. The calculated sample size was 22, which was raised up to 60 (30 in each group).

Inclusion Criteria

- Patient of either gender aged between 18-65 years
- Patient diagnosed with unilateral, closed mandibular angle fracture
- Patient with ASA physical status of I or II
- Patient who willing participate in the study with written consent.

Exclusion Criteria

- Patient with open or comminuted fractures
- Patient with pre-existing facial deformities
- Patient with systemic diseases affecting bone healing or surgical outcome
- Patient who is pregnant or breast feed
- Patient who has known allergy to titanium or related material

The ethical approval from institutional review board of Karachi Medical and Dental College was obtained. The written informed consent was signed by study participants who fulfil the inclusive criteria. All the participants were assured confidentiality, and adverse events were monitored and reported in accordance with institutional protocols. The participants were randomly assigned into two groups using sealed enveloped method:

Group 1: Open reduction and internal fixation using 3D titanium plates
Group 2: Open reduction and internal fixation using conventional miniplates

The sealed envelopes were opened only at the time of surgery by operating surgeon. All surgeries were performed under general anesthesia by single experienced oral and maxillofacial surgeon to maintain procedural consistency. A standardized intraoral approach was used in both groups. Fracture reduction and fixation were carried out according to group allocation. Postoperative instruction, antibiotics protocols and analgesic regimens were standardized across both groups. The operative time was recorded in minutes using calibrated stopwatch from initial incision to final wound closure. The data were collected preoperatively and postoperatively using structured proforma. The postoperative follow up was done on day 1, day 7 and after one month of surgery. The data analysis was done using SPSS version 23. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 60 participants were included in the study, which were randomly allocated in two groups (30 in each group). Table 1 showed the demographics of study participants of both groups (Table 1). The clinical outcomes were evaluated at three time points postoperatively: Day 1, Day 7 and Day 30. The interincisal distance on all three days of conventional plating group showed greater mean compared to 3D plating group whereas the pain score on all three days of 3D plating group showed lower levels compared to conventional plating group. Both outcomes were statistically significant as well (Table 2). Figure 1 showed the mean duration of surgery of both the groups. The postoperative infection rate was assessed clinically at day 7 and day 30 in both groups. From 30 participants, 5 participants shows infection at day 7 in conventional plating group whereas 2 participants shows infection in 3D plating group, which was reduced at day 30 in both groups (Table 3).

Table 1

Demographic Characteristics of Study Groups

Variable	Category	3D Plate	Conventional
Mean Age (years)		32.8 ± 8.4	33.2 ± 9.1
Gender	Male	20	21
	Female	10	9
Mechanism of Injury	Road Traffic Accident	56.7%	60.0%
	Fall	26.7%	23.3%
	Assault	16.6%	16.7%

Figure 1

Duration of Surgery

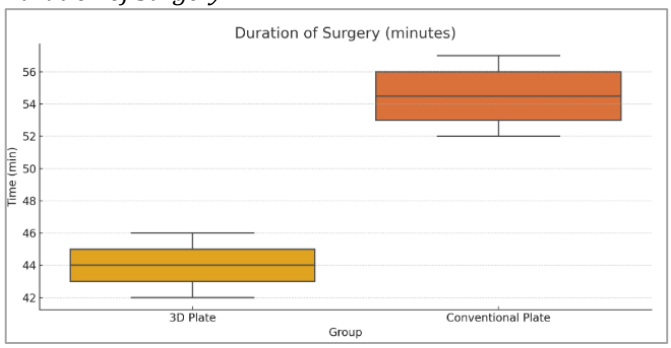

Table 2

Comparison of Clinical Outcomes between Groups

Outcome	Time	3D Plate (Mean ± SD)	Conventional (Mean ± SD)	p-value
Mouth Opening (mm)	Day 1	24.00 ± 0.83	27.43 ± 1.14	0.024
	Day 7	28.50 ± 0.51	31.00 ± 0.83	
	Day 30	36.20 ± 1.32	37.50 ± 1.41	
Pain Score	Day 1	5.50 ± 0.51	6.50 ± 0.51	0.035
	Day 7	2.50 ± 0.51	3.50 ± 0.51	
	Day 30	0.50 ± 0.51	1.00 ± 0.59	

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Duration of Surgery (min)	44.0 ± 1.4	54.5 ± 1.7	<0.001

Table 3

Postoperative Infection Rates

Time Point	Group 1 (3D Plate)	Group 2 (Conventional)	p-value
Day 7	2 patients (6.7%)	5 patients (16.7%)	0.421
Day 30	1 patient (3.3%)	2 patients (6.7%)	0.552

DISCUSSION

This randomized controlled trail compared the efficacy of 3D titanium plates with conventional miniplates in managing closed unilateral mandibular angle fractures. A systemic review of anterior mandibular fractures reported a weighted mean difference of -2.71 minutes favoring 3D plate systems. It resembles our study finding in which 3D plates surgery has shorter surgical time (13). Wiley-published research comparing 3D to conventional plates showed mean operating times of 37.3 min vs. 53.6 min, respectively. Meanwhile, a Pakistan RCT found 3D plating reduced operating duration by ~3 minutes in angle fractures. These metrics align with the principle that the unified 3D construct avoids the need for contouring two separate plates, streamlining the procedure (10). Although pain is less frequently quantified in fracture trials, biomechanical insights support fewer screws and minimal soft-tissue disruption with 3D plates, which could mitigate nociceptive input (13). Studies tracking functional recovery after angle fractures also show quicker improvements in mouth opening following 3D fixation (10). Our results reflect this trend, with reduced pain scores and functional calls on Day 7 and Day 30. The 6.7% infection rate in our 3D group is consistent with meta-analysis data reporting 0–9% rates for 3D systems; conventional systems often show slightly higher rates. Jain et al. reported similar infection rates in a randomized trial (7% vs. 10.7%; $p > 0.05$). While not statistically significant, the trend in our study aligns with the idea that the 3D plate's closed-box design stabilizes fragments more evenly, reducing micro-motion and potential contamination (12). A study by Tazeem Ul Hassnain et al. in Lahore observed lower occlusal discrepancy in the 3D cohort (11% vs. 31%), supporting improved stability (14). Biomechanically, 3D plates distribute forces across tension, compression, and torsional axes—something linear miniplates struggle to maintain (10). Retrospective analysis of different 3D designs also revealed that square (1.0 mm thick) plates delivered stable fixation with fewer complications compared to thicker triangular plates (15). The majority of positive operative time data favors 3D plates, but exceptions exist depending on plate geometry and surgeon experience. A triangular plate required significantly more time in a Swiss study ($p = 0.037$), reflecting a learning curve and adaptation difficulty (10).

Our study focused solely on angle fractures and involved a single experienced surgeon, minimizing anatomical or technical variability concerns. While plate unit cost may favor conventional miniplates, 3D systems often need only half the number of screws and save OR time (16). In resource-limited settings such as Abbasi Shaheed Hospital / KMDC, OR efficiency can offset hardware expenses and justify adopting 3D systems as first-line options. Our data strengthen the argument for adopting 3D titanium plates for mandibular angle fractures in resource-limited settings. Benefits span operative efficiency, patient comfort, and possibly lower complication rates—all while matching conventional outcomes in healing and functionality. Nevertheless, context matters—plate geometry and operator familiarity influence outcomes, and thicker or complex 3D designs may negate time savings in less experienced hands. The strength of the study is its randomized design with concealed allocation, single-surgeon procedures, and consistent follow-up enhance internal validity. The limitation of the study is its short term follow up. A larger sample for robust analysis should be done. The sole focus on angle fractures limits generalizability to other mandibular regions. In future multicenter randomized trials with 6-12 months follow up are needed to assess long term outcomes such as hardware failure, malocclusion, and cost-benefit analyses. A comparative studies of specific 3D geometries (square vs. triangular vs. C-shaped) can clarify design driven performance differences in clinical and biomechanical dimensions. Our study endorses 3D titanium plates as a valid, if not superior, alternative to conventional miniplates for unilateral mandibular angle fractures—delivering faster surgeries, less postoperative pain, and potentially reduced complication rates without compromising functional healing. These findings align with a growing body of evidence that underscores the mechanical and practical advantages of 3D plating systems, particularly in high-volume public healthcare environments.

CONCLUSION

This randomized controlled trial highlights the clinical benefits of three-dimensional (3D) titanium plates over conventional miniplates in managing closed unilateral mandibular angle fractures. Patients in the 3D plate group showed significantly shorter operative times, lower postoperative pain, and fewer complications, with comparable functional outcomes such as mouth opening. Although the difference in infection rates was not statistically significant, the trend favored 3D plates. These results align with existing international studies, supporting the mechanical and practical advantages of 3D systems. Their ease of application, stability, and reduced hardware requirements make them an effective and efficient option in oral and maxillofacial trauma care.

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