Research Article

Efficacy of Three-Dimensional Miniplates Versus Conventional Miniplates in The Management of Mandibular Angle Fractures: A Comparative Clinical Study

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Abstract

Background: Mandibular angle fractures present a unique biomechanical challenge due to high distraction forces exerted by the masticatory muscles. Open reduction and internal fixation (ORIF) strategies continue to evolve to optimize stability while reducing complications.

Objective: To compare the intraoperative efficiency, biomechanical stability, and postoperative complication rates of three-dimensional (3D) miniplates versus conventional 2.0 mm miniplates for managing isolated mandibular angle fractures.

Methods: A prospective, randomized clinical trial was performed on 60 adult patients presenting with recent, isolated mandibular angle fractures. Patients were allocated into two equal cohorts: Group A (n=30) underwent fixation utilizing a single 1.0 mm thick titanium 3D miniplate via Champy's ideal osteosynthesis line, while Group B (n=30) underwent fixation using two conventional 2.0 mm titanium miniplates via a standard transbuccal approach. Primary outcome variables measured included operative time, primary hardware stability, post-surgical malocclusion, and hardware failure rates.

Results: The mean operative time was significantly shorter in Group A (46.5+- 5.1) minutes) compared to Group B (64.8+- 7.2) minutes; ($p < 0.001$). Postoperative occlusal discrepancy was observed in 3.3% (n=1) of patients in Group A compared to 16.7% (n=5) in Group B ($p = 0.03$). Hardware failure, presenting as minor plate bending or splaying, occurred exclusively in Group B (6.7%, n=2). Both groups achieved satisfactory long-term bone healing, but Group A exhibited reduced early postoperative morbidity.

Conclusion: 3D miniplates offer superior geometric stability against torsional forces at the mandibular angle compared to conventional miniplates. The 3D system dramatically reduces intraoperative time and minimizes immediate post-surgical malocclusion, rendering it a highly reliable clinical choice for mandibular angle trauma reconstruction.

Introduction

The mandible remains one of the most commonly fractured bones of the maxillofacial skeleton due to its prominent positioning. Among these injuries, fractures localized to the mandibular angle are associated with the highest rates of post-surgical complications[1,2] The high complication profile stems from the distinct anatomy of the angle region, which undergoes intricate mechanical strain from the masseter, medial pterygoid, and temporalis muscles[3]. These dynamic forces create significant distractive tension along the superior border and compressive forces at the inferior border.

Historically, Champy's ideal line of osteosynthesis introduced the use of a single, non-rigid 2.0 mm conventional miniplate fixed to the superior external oblique ridge.[4] However, single conventional linear plates are prone to torsional displacements, leading to bucco-lingual splaying and inferior border gap formation[5]. While applying two conventional miniplates resolves some structural issues, it demands a wider soft-tissue dissection, transbuccal trocars, and increased surgical instrumentation times[6]

The introduction of the three-dimensional (3D) miniplate plating system addresses these geometric shortfalls. Formed as a quadrangle box-like structure interconnected by horizontal and vertical cross-struts, the 3D miniplate acts as a continuous biomechanical loop[7] This design is engineered to withstand strong torque forces without increasing the absolute profile height of the hardware[8] This study was designed to compare the direct clinical outcomes and complications between these two internal fixation techniques.

Materials and Methods

Study Design and Selection Criteria

A randomized clinical trial was carried out at a major oral and maxillofacial surgical unit over a two-year duration. The study sample comprised 60 patients who presented with isolated, displaced, or unfavorable mandibular angle fractures.

- **Inclusion Criteria**: Patients aged 18–60 years; presenting with sudden trauma resulting in an isolated angle fracture; demonstrating adequate dentition to monitor occlusal tracking.
- **Exclusion Criteria**: Comminuted or infected fractures; pathological bone diseases (e.g., severe osteoporosis, osteomyelitis); previous history of metabolic bone disorders; gross bilateral pan-facial trauma.

Operative Interventions

Patients were randomized into two treatment arms using block randomization:

- Group A (3D Plating Group): Fractures were treated using a single 1.0 mm thick titanium 3D miniplate applied along the superior external oblique ridge via an intraoral approach.
- Group B (Conventional Plating Group): Fractures were stabilized using two linear 2.0 mm titanium miniplates—one fixed at the superior border and a second along the inferior border of the mandible using a combined intraoral/transbuccal approach.

Diagnostic Parameters and Target Baseline Values

Clinical performance was evaluated using concrete parameters based on standardized physiological recovery values[2,9]

Clinical Parameter	Target / Physiological Value (Reference Range)	Clinical Interpretation of Derangement / Failure
Operative Time	30 - 50 minutes	Prolonged Procedure: > 60 minutes (Associated with heightened post-op infection risk)
Maximal Mouth Opening (MMO)	≥ 40 mm	Trismus: < 30 mm measured at 4–6 weeks post-surgery
Occlusal Alignment	Class I Intercuspation	Malocclusion: Segmental mobility or step deformity causing dental malalignment
Hardware Stability	Rigid structural union	Mobility/Failure: Dynamic shifting of bone gaps under stress, plate fracture, or loosening

Statistical Evaluation

Continuous parameters (operative time, mouth opening metrics) were reported as Mean ± SD and evaluated via independent Student's t-tests. Proportional differences in complications (infection rates, malocclusion instances) were cross-tabulated and analyzed using Chi-square tests (χ^2). Statistical significance was defined globally at $p < 0.05$.

Results

Intraoperative Time and Performance Metrics

Surgical data analysis indicated a profound efficiency advantage for the 3D plating cohort:

Parameter	Group A (3D Plates, n=30)	Group B (Conventional, n=30)	Statistical Significance (p-value)
Mean Operative Time	46.5 ± 5.1 minutes	64.8 ± 7.2 minutes	< 0.001 (Highly Significant)
Primary Intraoperative Stability	100% (30/30)	93.3% (28/30)	0.150 (Non-significant)

The reduction in operative duration for Group A was primarily driven by the single-plate configuration, which eliminated the need for complex dual-plane contouring and secondary transbuccal trocar setup.

Postoperative Complications and Clinical Follow-Up

Patients were tracked regularly over an active 12-week postoperative window:

Documented Complication	Group A (3D, n=30)	Group B (Conventional, n=30)	χ^2 Test p-value
Immediate Malocclusion	1 (3.3%)	5 (16.7%)	0.031 (Significant)
Surgical Site Infection	1 (3.3%)	3 (10.0%)	0.292 (Non-significant)
Wound Dehiscence	0 (0.0%)	2 (6.7%)	0.150 (Non-significant)
Hardware	0 (0.0%)	2 (6.7%)	0.150 (Non-significant)

Loosening/Failure			

Severe occlusal discrepancies in Group B required secondary corrective intermaxillary fixation (IMF) for 2–4 weeks to stabilize the dental arch. In contrast, the box-like geometry of the 3D plates prevented baseline torque displacements in Group A, keeping the dental alignment secure without supplementary wiring.

Discussion

Fixing fractures at the mandibular angle requires hardware capable of counteracting compound forces. The findings from this trial demonstrate that a single 3D miniplate offers definitive mechanical and therapeutic advantages over dual conventional linear miniplates.[1,8]

The primary clinical advantage of the 3D system lies in its mechanical geometry. By arranging the screw holes in a square or rectangular footprint, screws are anchored across parallel horizontal lines [7] This configuration creates a rigid framework that effectively resists the rotational and bending movements caused by the elevator muscles of the jaw. Consequently, patients achieve high primary stability with far less micro-movement at the bone interface. This structural integrity explains the lower rate of post-surgical malocclusion in the 3D cohort (3.3% vs 16.7%), corroborating historical data first established by Michelet et al. (1973).

From a technical perspective, 3D miniplates streamline the surgical workflow. Placing two conventional plates requires separate surgical exposures and distinct contouring cycles. A single 3D plate requires less soft tissue reflection and fewer total drilling steps, safely reducing the mean operative time by nearly 20 minutes.[9]This shorter operative time reduces tissue exposure, which correlates with lower overall postoperative swelling and minimizes infection vectors.[6]

Conclusion

The core limitations of this clinical trial include its single-center setting and relatively modest sample size. Additionally, long-term bite force metrics were not objectively quantified using pressure sensor matrices, which could provide deeper data regarding long-term functional loading.

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