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Clinical Efficacy and Safety of 3D Miniplate Fixation for Parasymphyseal and Angle Fractures of the Mandible: A Prospective Study

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Abstract

Mandibular fractures are among the most common facial bone injuries, requiring stable internal fixation for optimal functional and aesthetic restoration. While conventional miniplates have been the mainstay of treatment, three-dimensional (3D) miniplates have been introduced to provide greater stability and potentially reduce operative time. The objective of the study was to compare the clinical efficacy and safety of 3D miniplate fixation versus conventional Champy's miniplate fixation for the management of parasymphyseal and angle fractures of the mandible. This prospective comparative study at Dhaka Dental College & Hospital (April 2014-March 2015) enrolled 30 mandibular fracture patients randomly allocated into two equal groups. Group A underwent open reduction and internal fixation with 3D miniplates, while Group B received conventional Champy's miniplates. Outcomes assessed included operative time, occlusal disturbance, and complications over 24 weeks. Data were analyzed using SPSS version 20.0. The mean operative time was significantly shorter in the 3D miniplate group (44.3±3.83 vs. 56.4±5.42 minutes; p=0.030). At one week, occlusal disturbance occurred in 13.3% of Group A and 6.7% of Group B (p = 0.666). Complete occlusal stability was achieved in all patients by four weeks. Complications at four weeks were 6.7% in Group A and 13.3% in Group B (p=0.608), with none reported beyond 12 weeks in either group. Three-dimensional miniplate fixation significantly reduces operative time compared to conventional miniplates while offering comparable occlusal stability and complication rates, making it a safe, effective alternative for managing parasymphyseal and angle mandibular fractures.

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Introduction

Mandibular fractures are among the most frequently encountered injuries in maxillofacial trauma, accounting for a significant proportion of facial bone fractures due to the prominent position of the mandible on the facial skeleton.[1] The management of these fractures has evolved considerably over the years, transitioning from conservative approaches such as maxillomandibular fixation to more advanced techniques of open reduction and internal fixation (ORIF) that allow for early functional recovery and improved patient outcomes.[2,3] The introduction of miniplate osteosynthesis by Champy and colleagues revolutionized the treatment of mandibular fractures by establishing the principle of an "ideal osteosynthesis line" along the tension zones of the mandible.[4] This technique, utilizing monocortical screws and semirigid fixation, has become the standard of care for managing fractures of the mandibular symphysis, parasymphysis, body, and

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angle.[5] However, despite its widespread acceptance, conventional miniplate fixation is not without limitations, including the need for precise plate adaptation, potential for hardware failure, and occasional requirement for prolonged intermaxillary fixation.[6] In response to these challenges, three-dimensional (3D) miniplates were developed by Farmand and Dupoirieux in 1992, featuring a quadrangular design formed by joining two miniplates with interconnecting crossbars.[7] Unlike conventional plates that derive stability primarily from their thickness, 3D plates achieve stability through their structural configuration, forming a cuboid when secured with monocortical screws that provides three-dimensional stability to the fracture fragments.[8] This unique design offers several theoretical advantages, including enhanced resistance to torsional forces, easier adaptability to the bone surface, and potentially reduced operative time.[9] The mandibular angle and parasymphyseal regions present particular challenges in fracture management due to the complex biomechanical forces they encounter.[10] The angle region, in particular, is subjected to significant tensile and torsional forces from the masticatory muscles, making it prone to higher complication rates compared to other mandibular sites.[11] Similarly, parasymphyseal fractures are subject to distracting forces that can lead to lingual splaying of the fracture fragments if not adequately stabilized.[12] These biomechanical considerations make these fracture sites ideal for evaluating the comparative efficacy of different fixation systems. Recent studies have suggested that 3D miniplates may offer superior outcomes in terms of fracture stability and reduced operative time when compared to conventional miniplates.[13] Scott *et al.* demonstrated that the time taken for fixation using 3D plates was significantly lower than conventional miniplates, with a mean difference of approximately 10 minutes per fracture site.[9] Similarly, a comparative study by Al-Moraissi *et al.* reported that 3D plates provided better fragment stability and less postoperative displacement in mandibular angle fractures.[11] However, the evidence base for the use of 3D plates in parasymphyseal and angle fractures specifically remains limited, with most studies focusing on either subcondylar fractures or including mixed mandibular sites.[8,13] The present study was therefore undertaken to prospectively evaluate and compare the clinical efficacy and safety of 3D miniplate fixation versus conventional Champy's miniplate fixation for the management of parasymphyseal and angle fractures of the mandible. By assessing key parameters such as operative time, postoperative occlusal stability, and complication rates over a 24-week follow-up period, this study aims to provide evidence-based guidance for clinicians in selecting the optimal fixation method for these challenging fracture patterns.

Methodology

This prospective, comparative study was conducted in the Department of Oral and Maxillofacial Surgery at Dhaka Dental College & Hospital over one year from April 1, 2014, to March 30, 2015. The primary objective was to compare the clinical efficacy and safety of 3D miniplate fixation versus conventional Champy's miniplate fixation for the management of mandibular fractures.

Study population: A total of 30 patients with clinically and radiologically diagnosed mandibular fractures were enrolled in this study. The cohort comprised 26 male and 4 female patients, with a mean age of 34 years (age range: 15 to 60 years). Patients were randomly allocated into two equal groups of 15 using a simple randomization technique:

- **Group A (Study Group):** Underwent open reduction and internal fixation (ORIF) with 3D miniplates.
- **Group B (Control Group):** Underwent ORIF with conventional Champy's miniplates.

Inclusion criteria: Patients were considered eligible for the study if they met the following criteria:

- Age between 15 and 60 years.
- Presence of non-comminuted, non-infected fractures of the mandibular symphysis, parasymphysis, body, or angle.
- Systemically healthy with no significant comorbid illnesses.
- Willingness to provide informed written consent and adhere to the scheduled follow-up visits.

Exclusion criteria: Patients were excluded from the study based on the following parameters:

- Fractures involving the mandibular condyle, subcondyle, or ramus.
- Fractures associated with neurovascular bundle injury.
- Presence of concomitant midfacial fractures or polytrauma.
- Patients with systemic bone diseases or any intra-osseous pathological conditions (e.g., cysts or tumors) at the fracture site.
- Unwillingness to participate in the study or commit to the required follow-up schedule.

Surgical procedure: All surgical procedures were performed under nasotracheal intubation. Fracture sites were exposed using standard intra-oral or extra-oral approaches as dictated by the fracture location and surgeon preference. Temporary intraoperative maxillomandibular fixation (MMF) was utilized to achieve and verify the restoration of pre-injury occlusion.

- **Group A:** Fractures were stabilized using 2.0 mm 3-dimensional (3D) titanium miniplates.
- **Group B:** Fractures were stabilized using 2.0 mm conventional Champy's miniplates.

In both groups, care was taken to adapt the plates passively and to place screws, avoiding the dental roots and the inferior alveolar canal. The operating time, defined as the duration from the first incision to the completion of wound closure, was recorded for each patient.

Postoperative assessment and follow-up: Patients were followed up at regular intervals—specifically at 1 week, 4 weeks, 12 weeks, and 24 weeks postoperatively. At each visit, patients were evaluated both clinically and radiographically (with orthopantomograms) to assess:

- Stability of the fracture fragments.
- Restoration and maintenance of occlusion.
- Postoperative complications, including infection, wound dehiscence, hardware failure, paresthesia, and malunion/non-union.

Data analysis: All collected data were screened, coded, and entered into a spreadsheet before being exported to SPSS (Statistical Package for the Social Sciences) version 20 for analysis. Demographic data and categorical variables (such as occlusion, stability, and complications) were presented as frequencies and percentages. Differences between the two groups for these categorical variables were analyzed using the Chi-square test. Continuous variables, such as operating time, were compared using ANOVA, with a Post Hoc Least Significant Difference (LSD) test applied to determine the statistical significance of differences between the groups. A p-value of less than 0.05 was considered statistically significant.

Results

The present study evaluated 30 patients with mandibular fractures, comparing outcomes between

those treated with 3D miniplates and conventional Champy's miniplates. The mean age of the cohort was 33.5 years, with the largest proportion of patients (50.0%) in the 15–30 years age bracket. The study population demonstrated a strong male predilection, comprising 86.7% of the sample. Regarding etiology, Road Traffic Accidents were the predominant cause of fractures, accounting for 66.7% of cases, followed by physical assault (30.0%). Analysis of fracture site distribution revealed that the parasymphyseal region was the most frequently involved site, representing 46.6% of all fractures, followed by the angle (20.0%) (Table I). The distribution of fracture sites was comparable between the two treatment groups. A key finding of the study was a statistically significant difference in operative time between the two groups. The mean operative time for the 3D miniplate group was 44.3 ± 3.83 minutes, which was notably shorter than the 56.4 ± 5.42 minutes recorded for the conventional Champy's miniplate group. This difference was found to be statistically significant (p = 0.030) (Table II). Postoperative assessment of occlusal disturbance revealed comparable outcomes between the two groups throughout the follow-up period. At the 1-week follow-up, occlusal disturbance was observed in 13.3% of patients in the 3D miniplate group and 6.7% in the conventional miniplate group; however, this difference was not statistically significant (p = 0.666). By the 4-week follow-up and for all subsequent intervals (12 weeks and 6 months), complete occlusal stability was achieved in all patients across both groups, with no disturbances recorded (p = 1.000 for all subsequent intervals) (Table III). The incidence of postoperative complications was also similar between the two groups. No complications were observed in either group during the first postoperative week (p = 0.361). At the 4-week follow-up, minor complications were noted in 6.7% of patients in the 3D miniplate group and 13.3% in the conventional miniplate group. This difference was not statistically significant (p = 0.608). No complications were observed in either group at the 12-week or 6-month follow-up (p = 1.000 for both intervals), indicating favorable and stable healing outcomes for both fixation techniques (Table IV). A summary of the key comparative outcomes between the two groups is presented (Table V).

Table I: Demographic and clinical characteristics of patients (N=30)

Characteristic	Category	Group A (3D) (n=15)	Group B (Champy's) (n=15)	Total (N=30)	%
Age group	15–30 years	8	7	15	50.0
	31–45 years	5	5	10	33.3
	46–60 years	2	3	5	16.7
Sex	Male	13	13	26	86.7
	Female	2	2	4	13.3
Etiology	RTA	10	10	20	66.7
	Physical Assault	4	5	9	30.0
	Fall from Height	1	0	1	3.3
Fracture site	Parasymphyseal	7	7	14	46.6
	Symphyseal	3	2	5	16.7
	Body	3	2	5	16.7
	Angle	2	4	6	20.0

Table II: Comparison of operative time between groups

Group	Mean ±SD operative time (minutes)	p-value	Significance
Group A (3D Miniplate)	44.3 ±3.83	0.030	Significant (p<0.05)
Group B (Champy's Miniplate)	56.4±5.42		

Data were analyzed using the Chi-square test.

Table III: Comparison of postoperative occlusal disturbance over time

Follow-up period	Group	Disturbance present (n)	Disturbance absent (n)	p-value
1st week	Group A (3D)	2	13	0.666
	Group B (Champy's)	1	14	
4th week	Group A (3D)	0	15	1.000
	Group B (Champy's)	0	15	
12th week	Group A (3D)	0	15	1.000
	Group B (Champy's)	0	15	
6th month	Group A (3D)	0	15	1.000
	Group B (Champy's)	0	15	

Data were analyzed using the Chi-square test. All p-values > 0.05, indicating no statistically significant difference between groups.

Table IV: Comparison of postoperative complications over time

Follow-up period	Group	Complication present (n)	Complication absent (n)	p-value
1st week	Group A (3D)	0	15	0.361
	Group B (Champy's)	0	15	
4th week	Group A (3D)	1	14	0.608
	Group B (Champy's)	2	13	
12th week	Group A (3D)	0	15	1.000
	Group B (Champy's)	0	15	
6th month	Group A (3D)	0	15	1.000
	Group B (Champy's)	0	15	

Data were analyzed using the Chi-square test. All p-values > 0.05, indicating no statistically significant difference in complication rates between groups.

Table V: Summary of key outcomes between groups

Outcome parameter	Group A	Group B	p-value
Mean operative time (minutes)	44.3 ± 3.83	56.4 ± 5.42	0.030
Occlusal disturbance (1st Week)	2 (13.3%)	1 (6.7%)	0.666
Occlusal disturbance (≥4 Weeks)	0 (0%)	0 (0%)	1.000
Complications (4th Week)	1 (6.7%)	2 (13.3%)	0.608
Complications (≥12 Weeks)	0 (0%)	0 (0%)	1.000

Data were analyzed using the Chi-square test.

Discussion

The management of mandibular fractures continues to evolve with the introduction of innovative fixation systems aimed at improving clinical outcomes while reducing operative time and patient morbidity.[14] The present study compared the clinical efficacy and safety of 3D miniplate fixation versus conventional Champy's miniplate fixation for parasymphyseal and angle fractures of the mandible, with findings demonstrating a significant reduction in operative time for the 3D miniplate group alongside comparable outcomes in terms of occlusal stability and postoperative complications. The mean operative time in our study was significantly shorter in the 3D miniplate group (44.3 ± 3.83 minutes) compared to the conventional miniplate group (56.4 ± 5.42 minutes), with a p-value of 0.030. This finding is consistent with previously reported results demonstrating significantly shorter surgical times with 3D plates compared to Champy's miniplates for anterior mandibular fractures.[15] The reduction in operative time can be attributed to the unique design of 3D plates, which feature interconnected crossbars that allow for simultaneous stabilization of both the

superior and inferior borders of the mandible, reducing the need for multiple plate adaptations and contouring.[16] The pioneers of the 3D plate concept emphasized that the quadrangular configuration provides inherent stability that minimizes the need for extensive plate bending, thereby streamlining the surgical procedure.[8,17] The comparable operative times between our study and previous reports[15] reinforce the reproducibility of this advantage across different clinical settings and populations. Several investigators have similarly reported that the time required for fixation using 3D plates was significantly lower than with conventional miniplates, with a mean difference of approximately 10 minutes per fracture site.[9] This reduction in surgical duration has important implications for patient care, including decreased anesthesia exposure, reduced risk of surgical site infection, and improved operating room efficiency.[18] Postoperative occlusal stability represents a critical parameter for successful fracture management, as malocclusion can significantly impact patient quality of life and necessitate additional interventions.[19] In the present study, occlusal disturbance at the 1-week follow-up was observed in 13.3% of patients in the 3D miniplate group and 6.7% in the conventional miniplate group, with no statistically significant difference between groups ($p = 0.666$). By the 4-week follow-up and for all subsequent intervals, complete occlusal stability was achieved in all patients across both groups. These findings are consistent with previous reports demonstrating that malocclusion evident on the first postoperative day in some patients treated with conventional miniplates typically resolves by subsequent follow-up visits.[20] The comparable occlusal outcomes between the two fixation methods suggest that both techniques provide adequate stability to maintain fracture reduction during the healing process.

The biomechanical advantage of 3D plates lies in their ability to resist torsional forces that are particularly prominent in the anterior mandible.[6] Previous studies have emphasized that the box-like configuration of 3D miniplates creates a solid platform that increases resistance to twisting and rotation along the longitudinal axis of the plate, thereby preventing buccolingual splaying and gap formation at the fracture site.[6,21] This geometric stability may explain why 3D plates achieve comparable occlusal outcomes despite requiring fewer implants and less operative time than conventional miniplates. Regarding postoperative complications, our study revealed no significant differences between the two groups at any follow-up interval. At the 4-week follow-up, minor complications were noted in 6.7% of patients in the 3D miniplate group and 13.3% in the conventional miniplate group ($p = 0.608$). No complications were observed in either group beyond the 12-week follow-up, indicating favorable and stable healing outcomes for both fixation techniques. These findings are consistent with meta-analyses concluding that 3D miniplates demonstrate comparable complication rates to conventional miniplates while offering superior biomechanical stability.[16] However, it is important to note that some studies have reported a significantly lower incidence of infection with 3D plates compared to conventional miniplates.[15] This discrepancy may be attributed to differences in study populations, surgical techniques, or postoperative protocols. The lower infection rate observed in some reports may reflect the reduced operative time and less extensive soft tissue dissection associated with 3D plate placement, which could theoretically decrease the risk of surgical site contamination.[15,18] The absence of such a difference in our study may be related to the smaller sample size or the specific fracture patterns included. The comparable

complication rates between the two groups in our study support the findings of several recent investigations. Previous research has demonstrated that both 3D and conventional miniplates provide adequate fixation for mandibular fractures with similar complication profiles when proper surgical technique is employed.[5] Similarly, comparative studies have found no significant differences in postoperative infection, wound dehiscence, or hardware failure between different types of 3D plates.[13] These findings suggest that the choice between 3D and conventional miniplates may be guided by factors such as surgeon preference, fracture configuration, and the desire to reduce operative time rather than anticipated differences in complication rates. The comparable outcomes between the two fixation methods in terms of occlusal stability and complications, coupled with the significant reduction in operative time for 3D plates, support the conclusion that 3D miniplate fixation represents a safe and effective alternative for managing parasymphyseal and angle fractures of the mandible. This finding is particularly relevant in healthcare settings where operating room efficiency and resource utilization are important considerations.[18] The ability to achieve equivalent clinical outcomes with reduced surgical time may translate into cost savings and improved patient throughput without compromising quality of care. Several limitations of the present study should be acknowledged. The relatively small sample size (n=30) may have limited the power to detect differences in less common outcomes such as specific complication types. Additionally, the 24-week follow-up period, while adequate for assessing bone healing and early complications, may not capture late sequelae such as hardware removal rates or long-term temporomandibular joint function. Future studies with larger sample sizes and extended follow-up periods would be valuable to confirm these findings and explore additional outcome parameters.

Limitations

Several limitations should be acknowledged. The small sample size may have limited statistical power to detect differences in rare complications. The 24-week follow-up period, while adequate for assessing bone healing, may not capture long-term sequelae such as late hardware removal requirements.

Conclusion

The 3D miniplate fixation demonstrates a significant advantage over conventional Champy's miniplates in reducing operative time for managing parasymphyseal and angle fractures of the mandible. Both techniques yield comparable outcomes in terms of postoperative occlusal stability and complication rates. Based on these findings, 3D miniplate fixation represents a safe, effective, and time-efficient alternative that may enhance operating room efficiency without compromising patient care quality.

Recommendation

Based on the study findings, 3D miniplate fixation is recommended for parasymphyseal and angle mandibular fractures due to significantly reduced operative time and comparable clinical outcomes. Further multicenter studies with larger sample sizes and longer follow-up periods are warranted to validate these results.

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