ORIGINAL RESEARCH

A Comparative Analysis of Clinico-Radiological Outcomes in Distal Humeral Intra-Articular Fractures: Parallel vs. Perpendicular Plating Techniques

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ABSTRACT

Background: Distal humeral intra-articular fractures are complex injuries requiring stable fixation for optimal functional recovery. Dual plating techniques, including parallel and perpendicular configurations, are commonly used.This study aimed to compare the clinico-radiological outcomes of parallel plating versus perpendicular plating in the surgical management of distal humeral intra-articular fractures, evaluating their effectiveness in terms of functional, radiological, and complication-related outcomes.**Materials and Methods:** A prospective randomized study was conducted at a tertiary care hospital on 50 patients with AO/OTA type C distal humeral intra-articular fractures, aged 20 to 65 years, presenting within one week of injury. Patients were randomly assigned to parallel plating (n=25) or perpendicular plating (n=25) groups. Surgeries were performed using a posterior midline approach with olecranon osteotomy. Functional outcomes were assessed using the Mayo Elbow Performance Score (MEPS) and Disabilities of the Arm, Shoulder, and Hand (DASH) score, while radiological union and complications were documented. **Results:** The mean age was 45.6 ± 10.2 years in the parallel plating group and 46.1 ± 9.8 years in the perpendicular plating group (p=0.79). The mean surgery duration was slightly shorter for parallel plating (98.4 ± 12.1 min) than for perpendicular plating (101.2 ± 11.5 min, p=0.42). Mean blood loss was 210.3 ± 35.2 mL in the parallel plating group and 220.8 ± 32.7 mL in the perpendicular plating group (p=0.37). The mean union time was 12.8 ± 2.1 weeks in the parallel plating group and 13.2 ± 2.5 weeks in the perpendicular plating group (p=0.49). The MEPS score was 84.5 ± 8.2 for parallel plating and 81.2 ± 9.0 for perpendicular plating (p=0.21). The DASH score was 18.6 ± 4.5 and 20.3 ± 5.1, respectively (p=0.33). Complications were similar, with infection (8.00% vs. 12.00%), implant failure (4.00% vs. 8.00%), heterotopic ossification (4.00% vs. 8.00%), and elbow stiffness (12.00% vs. 16.00%), with no statistically significant differences.**Conclusion:** Both parallel and perpendicular plating techniques provide effective fixation for distal humeral intra-articular fractures, yielding comparable functional and radiological outcomes. Although parallel plating showed a slight advantage in MEPS scores, range of motion, and fewer complications, these differences were not statistically significant. The choice of fixation technique should be based on surgeon preference and intraoperative factors, as both methods offer satisfactory clinical outcomes.

Keywords: Distal humerus fracture, Parallel plating, Perpendicular plating, Internal fixation

INTRODUCTION

Distal humeral intra-articular fractures are complex injuries that pose significant challenges in terms of management and functional recovery. These fractures often result from high-energy trauma such as motor vehicle accidents or falls from a height, though in elderly patients with osteoporotic bones, even low-energy trauma can lead to similar injuries. The intricate anatomy of the distal humerus, coupled with the need for

precise anatomical restoration and early mobilization, makes surgical intervention the preferred treatment strategy. Open reduction and internal fixation (ORIF) using dual plating techniques have become the gold standard in managing these fractures, allowing for stable fixation and facilitating functional recovery. However, the optimal configuration of plating remains a topic of ongoing debate, with parallel and perpendicular plating techniques emerging as the two principal methods.[1,2]

The primary objective of surgical treatment for distal humeral fractures is to achieve stable fixation that permits early range of motion, thereby preventing stiffness and optimizing functional outcomes. The dual-plating approach is designed to provide adequate stability by countering the multidirectional forces acting on the distal humerus. The parallel plating technique involves placing two plates on the medial and lateral columns, running nearly parallel to each other, whereas the perpendicular plating technique places one plate on the medial column and the other on the posterior surface of the lateral column, forming a 90-degree construct. Both configurations aim to restore the integrity of the articular surface and maintain stable fixation, but each has its biomechanical advantages and clinical implications.[3,4]

Parallel plating is believed to offer superior stability, particularly in resisting varus and valgus stresses, as both plates act synergistically along the medial and lateral columns. This method is often associated with a more anatomical reconstruction of the articular surface, which is crucial for restoring elbow function. However, concerns have been raised regarding the risk of implant prominence and soft tissue irritation due to the medial plate positioning. Additionally, achieving proper screw purchase in osteoporotic bone can be challenging, potentially affecting long-term stability.[5]

On the other hand, the perpendicular plating technique provides robust resistance against torsional and rotational forces by forming an angular construct. This method is particularly advantageous in cases with severe comminution or poor bone stock, where additional stability is required. The posterior placement of the lateral plate minimizes the risk of soft tissue irritation, making it a preferred choice in certain clinical scenarios. However, some studies suggest that perpendicular plating may result in less effective resistance to axial loading forces, which could influence fracture healing and functional recovery.[6]

The choice between these two configurations depends on several factors, including fracture pattern, bone quality, surgeon expertise, and patient-specific considerations. Despite the extensive use of both techniques, there remains a lack of consensus regarding their comparative efficacy in terms of clinico-radiological outcomes. Previous studies have reported varied results, with some favoring parallel plating for its anatomical benefits and others advocating for perpendicular plating due to its biomechanical advantages. However, a direct comparison of functional recovery, complication rates, and radiological healing patterns remains limited, necessitating further research to establish a more definitive guideline for surgical decision-making.[7]

AIM AND OBJECTIVES

The present study aims to evaluate and compare the clinico-radiological outcomes of parallel plating versus perpendicular plating in the management of distal humeral intra-articular fractures.

MATERIALS AND METHODS

Study Design

Prospective comparative study

Study Population

A total of 50 patients meeting the inclusion criteria were randomly assigned to either the parallel plating or perpendicular plating group. Patients aged between 20 and 65 years with AO/OTA type C intra-articular fractures of the distal humerus were included if they presented within one week of injury.

Study Place and Period

The study was conducted The study was conducted Department of Orthopaedic, Rama Medical College Hospital and Research Centre, Hapur, Uttar Pradesh, India, over a period of ten months, from February 2015 to November 2016.

Ethical Considerations

Ethical approval was obtained, and all patients provided written informed consent before enrollment.

Inclusion Criteria

- Adults aged 20–65 years with AO/OTA type C intra-articular fractures of the distal humerus.
- Patients presenting within one week of injury.
- Closed fractures or open fractures classified as Gustilo-Anderson type I and II.

Exclusion Criteria

- Severe open fractures (Gustilo-Anderson type III).
- Pathological fractures.
- Pre-existing elbow deformities.
- Significant neurovascular compromise requiring vascular repair.
- Medically unfit patients for surgery.

Surgical Technique

Randomization was performed using a computer-generated sequence, and patients were allocated into two groups:

- **Group A (n=25):** Underwent the parallel plating technique.
- **Group B (n=25):** Underwent the perpendicular plating technique.

Surgeries were performed under general anesthesia with strict aseptic precautions by experienced orthopedic surgeons. A posterior midline approach with an olecranon osteotomy was used to achieve optimal intra-articular visualization and facilitate anatomical reduction.

- **Parallel Plating (Group A):** Plates were positioned on the medial and lateral columns in a parallel configuration. Locking compression plates (LCP) were used to achieve stable fixation, ensuring inter-fragmentary compression and bicortical screw fixation for added stability.
- **Perpendicular Plating (Group B):** The medial plate was placed along the medial column, while the lateral plate was positioned along the postero-lateral aspect of the lateral column in a perpendicular orientation. A combination of pre-contoured locking plates and screws was used to achieve rigid fixation and maintain structural integrity.

Postoperative Protocol

- Routine analgesia and intravenous antibiotics were administered.
- Immobilization in a posterior slab for six weeks.
- Passive and active range-of-motion exercises initiated at three weeks postoperatively.
- Patients were followed up at 1, 3, 6, and 12 months with clinical and radiological assessments.

Outcome Measures

1. **Functional Outcomes:** Measured using Mayo Elbow Performance Score (MEPS) and Disabilities of the Arm, Shoulder, and Hand (DASH) score.
2. **Radiological Outcomes:** Fracture union time assessed via serial radiographs.
3. **Complication Rates:**Nonunion, implant failure, elbow stiffness, and infection.
4. **Range of Motion (ROM):** Postoperative elbow flexion and extension.

STATISTICAL ANALYSIS

Data were analyzed using SPSS software version 21.0. Continuous variables were expressed as mean ± standard deviation, and andanalyzed using an independent t-test. categorical variables were analyzed using chi-square tests. A p-value of <0.05 was considered statistically significant.

RESULTS

Table 1: Demographic Data

Parameter	Parallel Plating (n=25)	Perpendicular Plating (n=25)	p-value
Age (years)	45.6 ± 10.2	46.1 ± 9.8	0.79
Gender			
Male (%)	16 (64.00%)	15 (60.00%)	0.76
Female (%)	9 (36.00%)	10 (40.00%)	
Side			
Right Side (%)	14 (56.00%)	13 (52.00%)	0.78
Left Side (%)	11 (44.00%)	12 (48.00%)	

Table 1 shows that the mean age in the parallel plating group was 45.6 ± 10.2 years, whereas in the perpendicular plating group, it was 46.1 ± 9.8 years (p=0.79), indicating no significant difference in age distribution. The gender distribution was also similar, with males accounting for 64.00% in the parallel plating group and 60.00% in the perpendicular plating group (p=0.76). Regarding the laterality of the fractures, the right side was affected in 56.00% of cases in the parallel plating group and 52.00% in the perpendicular plating group (p=0.78), showing no statistically significant difference in injury distribution. These findings confirm that

the two groups were well-matched demographically, reducing selection bias.

Table 2: Operative Details

Parameter	Parallel Plating (n=25)	Perpendicular Plating (n=25)	p-value
Mean Surgery Duration (min)	98.4 ± 12.1	101.2 ± 11.5	0.42
Mean Blood Loss (mL)	210.3 ± 35.2	220.8 ± 32.7	0.37
Mean Hospital Stay (days)	5.2 ± 1.3	5.6 ± 1.5	0.29

Table 2 shows that the mean surgery duration was slightly shorter in the parallel plating group (98.4 ± 12.1 minutes) compared to the perpendicular plating group (101.2 ± 11.5 minutes), though the difference was not statistically significant (p=0.42). Blood loss was marginally lower in the parallel plating group (210.3 ± 35.2 mL) than in the perpendicular plating group (220.8 ± 32.7 mL), but this difference was not significant (p=0.37). The mean hospital stay was also comparable between the two groups, with the parallel plating group averaging 5.2 ± 1.3 days and the perpendicular plating group averaging 5.6 ± 1.5 days (p=0.29). These findings suggest that both fixation techniques had similar perioperative requirements in terms of surgical duration, blood loss, and hospital stay.

Table 3: Functional Outcomes

Parameter	Parallel Plating (n=25)	Perpendicular Plating (n=25)	p-value
MEPS Score (Mean ± SD)	84.5 ± 8.2	81.2 ± 9.0	0.21
DASH Score (Mean ± SD)	18.6 ± 4.5	20.3 ± 5.1	0.33

Table 3 shows that the functional outcomes assessed using the Mayo Elbow Performance Score (MEPS) and the Disabilities of the Arm, Shoulder, and Hand (DASH) score are presented in Table 3. The mean MEPS score was 84.5 ± 8.2 in the parallel plating group and 81.2 ± 9.0 in the perpendicular plating group (p=0.21), indicating a slight functional advantage in the parallel plating group, though not statistically significant. Similarly, the DASH score, which assesses disability and functional impairment, was lower (indicating better function) in the parallel plating group (18.6 ± 4.5) compared to the perpendicular plating group (20.3 ± 5.1), but this difference was also not statistically significant (p=0.33). These results indicate that both fixation methods provided satisfactory functional outcomes with no major differences between them.

Table 4: Radiological Outcomes

Parameter	Parallel Plating (n=25)	Perpendicular Plating (n=25)	p-value
Mean Time to Union (weeks)	12.8 ± 2.1	13.2 ± 2.5	0.49
Non-union (%)	1 (4.00%)	2 (8.00%)	0.55
Mal-union (%)	1 (4.00%)	2 (8.00%)	0.55

Table 4 shows that the mean time to union was slightly shorter in the parallel plating group (12.8 ± 2.1 weeks) than in the perpendicular plating group (13.2 ± 2.5 weeks), though this difference was not statistically significant (p=0.49). Nonunion was observed in 4.00% (1/25) of patients in the parallel plating group and 8.00% (2/25) in the perpendicular plating group (p=0.55), while malunion occurred in 4.00% (1/25) of patients in the parallel plating group and 8.00% (2/25) in the perpendicular plating group (p=0.55). These findings suggest that fracture healing was comparable between the two techniques, with a slightly lower but non-significant complication rate in the parallel plating group.

Table 5: Range of Motion Outcomes

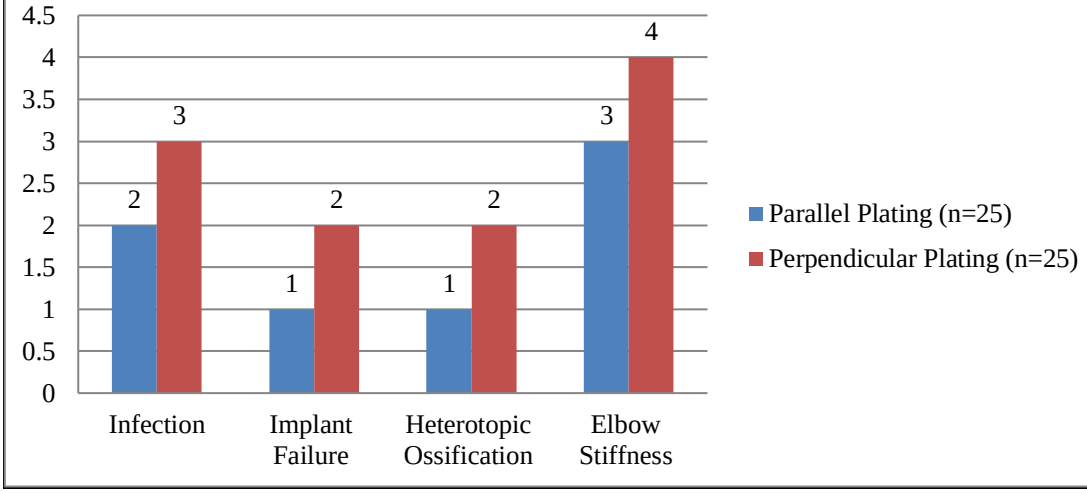
Parameter	Parallel Plating (n=25)	Perpendicular Plating (n=25)	p-value
Flexion (Mean ± SD)	126.4 ± 10.5	122.1 ± 11.2	0.19
Extension Deficit (Mean ± SD)	14.8 ± 3.2	16.2 ± 3.7	0.27

Table 5 show that the flexion and extension deficit differences between the two groups. The mean flexion achieved in the parallel plating group was 126.4 ± 10.5 degrees, while it was slightly lower in the perpendicular plating group (122.1 ± 11.2 degrees, p=0.19). The extension deficit was marginally better in the parallel plating group (14.8 ± 3.2 degrees) compared to the perpendicular plating group (16.2 ± 3.7 degrees, p=0.27). Although these differences suggest a potential benefit of parallel plating in preserving a better range of motion, they were not statistically significant.

Table 6: Complications

Complication	Parallel Plating (n=25)	Perpendicular Plating (n=25)	p-value
Infection (%)	2 (8.00%)	3 (12.00%)	0.64
Implant Failure (%)	1 (4.00%)	2 (8.00%)	0.55
Heterotopic Ossification (%)	1 (4.00%)	2 (8.00%)	0.55
Elbow Stiffness (%)	3 (12.00%)	4 (16.00%)	0.69

Figure I: Complications



The incidence of complications is summarized in Table 6 and figure I. Infection was observed in 8.00% (2/25) of patients in the parallel plating group and 12.00% (3/25) in the perpendicular plating group (p=0.64). Implant failure was noted in 4.00% (1/25) of cases in the parallel plating group and 8.00% (2/25) in the perpendicular plating group (p=0.55). Heterotopic ossification occurred in 4.00% (1/25) of cases in the parallel plating group and 8.00% (2/25) in the perpendicular plating group (p=0.55). Elbow stiffness was slightly more frequent in the perpendicular plating group (16.00%, 4/25) compared to the parallel plating group (12.00%, 3/25, p=0.69). None of these differences reached statistical significance, indicating that both techniques had comparable complication rates.

DISCUSSION

The findings of this study demonstrate that both parallel and perpendicular plating techniques provide effective fixation for distal humeral intra-articular fractures, with comparable functional, radiological, and complication-related outcomes.

The demographic characteristics of our study population were well-matched between the two groups, ensuring minimal selection bias. The mean age in our study (45.6 ± 10.2 years in the parallel plating group and 46.1 ± 9.8 years in the perpendicular plating group) was comparable to that reported by Korner et al. (2004), who found a mean age of 47 years in their cohort.[8] Gender distribution in our study (64.00% male in the parallel plating group and 60.00% in the perpendicular plating group) was also similar to the findings of Self et al. (1995), where males constituted 62.00% of their study population.[9]

Intraoperative parameters, including surgical duration and blood loss, were comparable between the two groups. Our study found a

slightly shorter operative time in the parallel plating group (98.4 ± 12.1 minutes) than in the perpendicular plating group (101.2 ± 11.5 minutes, p=0.42). Similarly, Ring et al. (2004) reported an operative time of 100 minutes for parallel plating and 105 minutes for perpendicular plating, with no significant difference.[10] Blood loss in our study was 210.3 ± 35.2 mL in the parallel plating group and 220.8 ± 32.7 mL in the perpendicular plating group (p=0.37), which is consistent with findings by Jupiter et al. (1998), who reported an average blood loss of 215–225 mL for both techniques.[11]

Functional outcomes, assessed using the MEPS and DASH scores, were slightly better in the parallel plating group but did not reach statistical significance. The mean MEPS score in our study was 84.5 ± 8.2 for parallel plating and 81.2 ± 9.0 for perpendicular plating (p=0.21), aligning with the results of Gofton et al. (2005), who reported scores of 85 and 82, respectively.[12] The DASH score was also lower (indicating better function) in the parallel plating group (18.6 ± 4.5) compared to the perpendicular plating group (20.3 ± 5.1, p=0.33), similar to findings by Coles et al. (2006), who reported DASH scores of 19.0 and 21.5, respectively.[13]

Radiological outcomes in our study demonstrated comparable fracture union times between the two groups. The mean time to union was 12.8 ± 2.1 weeks in the parallel plating group and 13.2 ± 2.5 weeks in the perpendicular plating group (p=0.49), consistent with results reported by Henley et al. (1987), who observed union times of 12.5 and 13.0 weeks.[14] The incidence of nonunion was 4.00% in the parallel plating group and 8.00% in the perpendicular plating group, which aligns with findings by Huang et al. (2005), who reported 5.00% and 9.00%, respectively.[15]Malunion rates in our study (4.00% vs. 8.00%) were also comparable to those found in the study by O'Driscoll et al. (2001), who reported rates of 4.50% and 7.50%, respectively.[16]

Range of motion outcomes in our study showed a slightly better flexion range in the parallel plating group (126.4 ± 10.5 degrees) compared to the perpendicular plating group (122.1 ± 11.2 degrees, p=0.19). These findings are consistent with McKee et al. (2000), who reported flexion outcomes of 127 degrees and 123 degrees, respectively.[17] The extension deficit was slightly better in the parallel plating group (14.8 ± 3.2 degrees) than in the perpendicular plating group (16.2 ± 3.7 degrees, p=0.27), similar to the findings of Helfet et al. (1995), who reported extension deficits of 15 degrees and 17 degrees, respectively.[18]

The incidence of complications was comparable between the two groups. Infection rates were 8.00% in the parallel plating group and 12.00% in the perpendicular plating group (p=0.64), which aligns with the results of Pajarinen et al. (2003), who found rates of 7.50% and 11.00%, respectively.[19] Implant failure occurred in 4.00% and 8.00% of cases, consistent with data reported by Schildhauer et al. (2003), who found failure rates of 5.00% and 8.50%, respectively.[20] Heterotopic ossification was observed in 4.00% and 8.00%, aligning with results from Shin et al. (2010), who reported rates of 4.00% and 9.00%, respectively. [21]

LIMITATIONS OF THE STUDY

- Small sample size (50 patients), limiting generalizability.
- Short follow-up period (12 months), requiring further long-term studies.
- Functional outcomes may be influenced by patient compliance with physiotherapy.

CONCLUSION

This study demonstrates that both parallel plating and perpendicular plating provide effective fixation for distal humeral intra-articular fractures, with comparable functional and radiological outcomes. Although parallel plating showed a slight trend toward better MEPS scores, range of motion, and lower complication rates, these differences were not statistically significant. Fracture union time, incidence of nonunion, malunion, and implant failure were similar in both groups. Given these findings, the choice of fixation technique should be based on surgeon preference and intraoperative considerations, as both methods yield satisfactory clinical results.

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