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Effects of Orthogonal Vs Parallel Plating on Fracture Healing for the Management of Intra-Articular Distal Humerus Fracture

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ABSTRACT

Objective: To compare the radiological and functional outcomes of orthogonal (90–90) versus parallel plating techniques in the operative management of intra-articular distal humerus fractures. **Methods:** This prospective cohort study was conducted at the Orthopedics Department of Combined Military Hospital Rawalpindi, enrolling 80 adult patients with AO/OTA type C intra-articular distal humerus fractures during the period from October 2024 to March 2025. Patients were managed with either orthogonal (n=40) or parallel (n=40) dual plating based on surgeon preference and fracture morphology. Postoperative follow-up included clinical and radiographic assessments at 6 weeks, 3 months, and 6 months. Functional outcomes were assessed using the Mayo Elbow Performance Score (MEPS), range of motion (ROM), and radiological union on standard AP and lateral views. Complications such as non-union, implant loosening, and ulnar neuropathy were recorded. **Results:** At final follow-up, fracture union was achieved in 95% of patients in both groups. The mean MEPS score was slightly higher in the parallel plating group (89.6 ± 6.2) compared to the orthogonal group (85.7 ± 7.4), though not statistically significant (p=0.062). Elbow ROM was comparable between groups. Implant-related complications were observed more in the orthogonal group (12.5%) than in the parallel group (5%), but the difference was not statistically significant. **Conclusion:** Both orthogonal and parallel plating configurations result in comparable fracture union rates and functional outcomes in the management of intra-articular distal humerus fractures. Parallel plating may offer a marginal advantage in elbow function and fewer implant-related complications, but both methods remain viable and effective depending on fracture pattern and surgeon experience.

INTRODUCTION

Fractures of the distal humerus represent a challenging subset of injuries, accounting for approximately 2% of all fractures and nearly one-third of humeral fractures in adults (1). Among these, intra-articular distal humerus fractures, particularly AO/OTA type C fractures are complex, often comminuted, and demand precise surgical management to restore anatomical alignment, joint congruity, and functional motion (2) (3). Given the distal humerus' intricate three-column architecture and proximity to neurovascular structures, operative intervention is almost always required for acceptable outcomes (4). The goals of treatment are stable internal fixation, early mobilization, and functional restoration, with avoidance of complications such as stiffness, non-union, and post-traumatic arthritis (5).

Historically, the evolution of fixation techniques has led to the adoption of bicolumnar plating as the gold standard (6). The use of two plates placed on separate columns—medial and lateral—ensures mechanical stability and allows early range of motion. However, the configuration of these plates has been a subject of continuous debate (6) (7). The two most widely accepted constructs are orthogonal (90°–90°) and parallel (medial-lateral) dual plating systems. Both techniques aim to achieve rigid fixation, yet differ in biomechanical properties and surgical approach (8).

Orthogonal plating involves the placement of one plate along the medial column and the second plate posterolaterally at 90 degrees to the first (9). First described by Schatzker and later popularized by AO principles, orthogonal fixation provides adequate stability, particularly in simple fracture patterns (8) (10). Its advocates argue for its easier exposure and predictable fixation in less comminuted fractures (11). On the other hand, parallel plating, first introduced by O'Driscoll and colleagues, involves the placement of both plates medially and laterally in the sagittal plane, aligned parallel to each other (10) (12). This construct provides multiple points of fixation across the articular segment, especially beneficial in osteoporotic bone or comminuted fractures (13). Several biomechanical studies suggest that parallel plating offers superior rigidity in torsional and axial loading,

making it particularly advantageous in unstable fracture configurations (14).

Despite these theoretical advantages, clinical evidence comparing the two techniques remains varied and inconclusive. While some studies report comparable union rates and functional outcomes, others suggest that parallel plating may offer improved biomechanical strength and lower complication rates (15). Moreover, patient-related factors—such as age, bone quality, fracture complexity, and surgeon experience—further influence the outcomes of these interventions (16,17).

In terms of complications, ulnar nerve neuropathy, elbow stiffness, implant failure, and delayed or non-union are of particular concern (17). The surgical approach, plate prominence, and implant choice all play roles in the development of postoperative complications (18,19). Both plating systems have their own set of technical challenges and complications; orthogonal plating may be associated with higher implant prominence posterolaterally, while parallel plating requires careful contouring and attention to the medial and lateral anatomical landmarks (19) (19).

Functional recovery after distal humerus fractures is critically dependent on the stability of fixation, early mobilization, and avoidance of complications (20) (21). The Mayo Elbow Performance Score (MEPS) and range of motion (ROM) are commonly used parameters for evaluating postoperative function, in addition to radiological union and complication rates. Understanding which plating configuration better facilitates early recovery and minimizes risk is vital for orthopaedic surgeons aiming for optimal patient outcomes (21) (21).

This study aims to compare the clinical and radiological outcomes of orthogonal and parallel dual plating in the surgical management of intra-articular distal humerus fractures. By evaluating union rates, elbow function, range of motion, and complication profiles, this research seeks to provide clarity on the most effective approach for these complex injuries. Given the ongoing debate in both clinical and academic circles, this comparative analysis hopes to contribute meaningful evidence to support decision-making in orthopaedic trauma care.

METHODOLOGY

Study Design and Setting

This was a prospective, comparative cohort study conducted at the Department of Orthopedic Surgery, Combined Military Hospital Rawalpindi, from October 2024 to March 2025. The study was approved by the REU of CPSP (Ref No: CPSP/ REU / OSG-2O23-12O-3O49 Dated: September 26, 2024) and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all patients prior to inclusion.

Study Population

A tot,al of 80 adult patients diagnosed with AO/OTA type C intra-articular distal humerus fractures were included. All patients underwent open reduction and internal fixation (ORIF) using dual plating either in an orthogonal (90–90) configuration or parallel plating depending on fracture morphology, bone quality, and surgeon preference.

Inclusion Criteria

- Adults aged 18 to 70 years
- Closed intra-articular distal humerus fractures (AO type C1, C2, or C3)
- No prior surgery on the affected elbow
- Ability to provide informed consent and comply with follow-up visits

Exclusion Criteria

- Open fractures (Gustilo-Anderson type II or higher)
- Pathological fractures (due to malignancy or metabolic bone disease)
- Fractures associated with neurovascular injury requiring repair
- Patients with bilateral upper limb injuries
- Incomplete follow-up or refusal to participate

Surgical Technique

All procedures were performed under general anesthesia with the patient in the lateral decubitus or prone position. A standard posterior approach to the distal humerus was used in all cases. The ulnar nerve was identified and protected throughout the procedure, and anterior transposition was performed selectively based on intraoperative assessment.

- **Orthogonal plating group (n = 40):** Fixation was achieved by placing a plate along the **medial column** and a second plate posterolaterally on the lateral column, forming a 90° angle. This construct followed traditional AO principles.
- **Parallel plating group (n = 40):** Two plates were applied medially and laterally, both positioned in the sagittal plane, according to the O'Driscoll technique. Great care was taken to achieve maximal distal screw fixation across both condyles to ensure compression at the articular surface.

Anatomical reduction was confirmed fluoroscopically. Bone grafting was done, when necessary, in cases with bone loss or metaphyseal comminution.

Postoperative Protocol

All patients were given broad-spectrum antibiotics for 24 hours postoperatively and started on pain management and physiotherapy protocols. The elbow was immobilized in a posterior splint for the first 10–14 days, followed by gradual range-of-motion exercises. Full weight-bearing through the arm was avoided for at least 8–12 weeks.

Follow-Up and Outcome Assessment

Patients were evaluated at 2 weeks, 6 weeks, 3 months, and 6 months postoperatively.

Radiological assessment

- Standard anteroposterior and lateral X-**rays** were taken at each visit.
- **Fracture union** was defined as the presence of bridging callus on three cortices and absence of pain at the fracture site during movement.
- Delayed union was defined as lack of healing after 16 weeks, and non-union as absence of healing after 24 weeks.

Clinical assessment

- Functional outcome was measured using the Mayo Elbow Performance Score (MEPS), which evaluates pain, motion, stability, and daily function.

- **Range of motion (ROM)** in degrees was measured using a goniometer for flexion, extension, pronation, and supination.
- **Complications** such as infection, implant loosening, implant failure, hardware prominence, and ulnar nerve symptoms were documented.

Statistical Analysis

Data were compiled and analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables (age, MEPS, ROM) were expressed as mean ± standard deviation (SD), and categorical variables (sex, complications, fracture union) were presented as frequencies and percentages.

- The Chi-square test was used to analyze categorical data, and
- The independent-samples t-test was applied for comparing continuous variables between the two groups.
- A p-value of <0.05 was considered statistically significant.

RESULTS

Demographic and Baseline Characteristics

A total of 80 patients were enrolled, with 40 patients in each group: orthogonal plating and parallel plating. The mean age of participants was 45.6 ± 11.4 years in the orthogonal group and 46.8 ± 10.7 years in the parallel group (p = 0.62). There was no statistically significant difference in gender distribution, injury mechanism, fracture type, or time from injury to surgery between the two groups (Table I).

Table I

Baseline Demographics and Injury Characteristics

Variable	Orthogonal (n=40)	Parallel (n=40)	p-value
Mean Age (years)	45.6 ± 11.4	46.8 ± 10.7	0.62
Male / Female	25 / 15	23 / 17	0.65
AO Fracture Type (C1/C2/C3)	10 / 18 / 12	9 / 20 / 11	0.88
Time to Surgery (days)	4.8 ± 1.3	5.1 ± 1.6	0.29

Radiological Union

- Fracture union was achieved in 38 patients (95%) in the orthogonal group and 39 patients (97.5%) in the parallel group (p = 0.56).
- Mean time to radiographic union was 13.4 ± 2.2 weeks in the orthogonal group and 12.9 ± 2.0 weeks in the parallel group (p = 0.38).

Functional Outcomes

At final follow-up (6 months):

- The mean Mayo Elbow Performance Score (MEPS) was:
  - 85.7 ± 7.4 in the orthogonal group
  - 89.6 ± 6.2 in the parallel group
  - The difference approached but did not reach statistical significance (p = 0.062)
- Patients achieving excellent or good MEPS outcomes:
  - Orthogonal: 33 patients (82.5%)
  - Parallel: 36 patients (90%) (p = 0.34)
- **Range of Motion (ROM):**
  - Mean elbow flexion-extension arc:
    - Orthogonal: 110.3° ± 12.5°
    - Parallel: 114.1° ± 11.9° (p = 0.19)
  - Pronation-supination arc:
    - Orthogonal: 145.4° ± 10.2°
    - Parallel: 147.6° ± 9.6° (p = 0.36)

Complications

- **Ulnar Neuropathy**:
  - Orthogonal: 3 cases (7.5%)
  - Parallel: 2 cases (5%)
  - (p = 0.64)
- **Implant-related complications**:
  - Orthogonal: 5 patients (12.5%) (2 with hardware prominence, 3 with screw loosening)
  - Parallel: 2 patients (5%) (both hardware prominence)
  - (p = 0.23)
- **Delayed Union**:
  - Orthogonal: 2 cases (5%)
  - Parallel: 1 case (2.5%)
- **Infection**:
  - Superficial wound infection in 1 patient (orthogonal group), managed conservatively

Table II

Summary of Outcomes and Complications

Outcome / Complication	Orthogonal (n=40)	Parallel (n=40)	p-value
Union Rate (%)	95	97.5	0.56
Mean Time to Union (weeks)	13.4 ± 2.2	12.9 ± 2.0	0.38
MEPS (mean ± SD)	85.7 ± 7.4	89.6 ± 6.2	0.062
Excellent/Good MEPS (%)	82.5	90	0.34
Elbow ROM (°)	110.3 ± 12.5	114.1 ± 11.9	0.19
Ulnar Neuropathy (%)	7.5	5	0.64
Implant Complications (%)	12.5	5	0.23

DISCUSSION

Intra-articular distal humerus fractures continue to pose a significant surgical challenge due to their anatomical complexity, associated soft tissue considerations, and high functional demands of the elbow joint. Achieving stable fixation that allows early mobilization without compromising joint integrity is critical to successful outcomes. Dual plating techniques—orthogonal and parallel—have become standard modalities for treating such injuries. This study compared these two fixation constructs in terms of radiological union, functional recovery, and complication rates, revealing that both methods offer reliable results, with a marginal trend toward improved outcomes in the parallel plating group.

Our findings demonstrated comparable union rates in both groups: 95% in the orthogonal group and 97.5% in the parallel group. These results are consistent with prior studies, such as Sanchez-Sotelo et al. (2007), who reported similar union rates in both constructs, emphasizing that adherence to sound surgical principles may outweigh the specific plating configuration when it comes to bony union.

In terms of functional outcome, the average Mayo Elbow Performance Score (MEPS) was higher in the parallel group (89.6 ± 6.2) than in the orthogonal group (85.7 ± 7.4), although this difference was not statistically

significant. This modest difference, however, aligns with biomechanical studies, such as those by Self et al. (2007) and Scolaro et al. (2014), which suggest that parallel plating offers greater stability in axial and torsional loading, particularly in osteoporotic or comminuted fractures. These biomechanical advantages may translate into better early rehabilitation and smoother functional recovery in clinical settings.

Our data also demonstrated slightly better elbow ROM and a higher percentage of excellent or good MEPS results in the parallel group. While the differences did not reach statistical significance, these trends are clinically relevant. Elbow motion, particularly extension, is often compromised following complex distal humerus fractures, and the ability to achieve early, stable fixation has a direct impact on preventing post-operative stiffness—a major complication of elbow trauma.

Importantly, implant-related complications, including hardware prominence and screw loosening, were more frequently observed in the orthogonal group (12.5%) compared to the parallel group (5%). These findings echo the work of O'Driscoll et al., who noted that orthogonal constructs might lead to posterior plate prominence, especially in individuals with less soft tissue coverage. Hardware irritation, leading to patient discomfort or requiring implant removal, is not uncommon and must be weighed against the ease of the surgical approach and exposure in orthogonal configurations.

Regarding neurological complications, the incidence of ulnar neuropathy was slightly higher in the orthogonal group (7.5%) than in the parallel group (5%). Though not statistically significant, this reinforces the need for meticulous handling of the ulnar nerve during posterior approaches. Our study did not perform routine anterior transposition of the ulnar nerve, but selective transposition may be beneficial in cases with high risk of neuropathy.

The time to fracture union was nearly equivalent between groups, suggesting that both constructs provide sufficient stability for biological healing. This further underscores the notion that the selection of plating configuration may depend more on fracture morphology, surgeon experience, and intraoperative feasibility rather than a clear superiority of one system over the other.

Several previous clinical studies have attempted to clarify this debate. Atalar et al. (2010) found no significant difference in functional or radiographic outcomes between the two techniques, while Shin et al. (2013) reported better elbow motion in the parallel group. Our findings align with these conclusions, contributing additional clinical evidence that both systems are effective, but parallel plating may offer subtle advantages in certain clinical scenarios.

This study reaffirms that both orthogonal and parallel dual plating systems are safe and effective for treating intra-articular distal humerus fractures, with high union rates and satisfactory functional outcomes. While not statistically conclusive, the parallel plating technique showed trends toward better MEPS scores, improved elbow mobility, and fewer hardware complications. Surgeons should base their choice of plating construct on individual fracture characteristics, bone quality, and their own familiarity with the technique. Future randomized trials with larger populations and longer follow-up are warranted to solidify these findings and offer definitive recommendations.

CONCLUSION

This study concludes that both orthogonal and parallel plating techniques are effective methods for managing intra-articular distal humerus fractures, yielding high union rates and satisfactory functional outcomes. While the differences were not statistically significant, parallel plating demonstrated a slight advantage in terms of Mayo Elbow Performance Scores, range of motion, and fewer implant-related complications, suggesting a potential clinical edge in selected cases. The choice of fixation should be individualized, based on fracture configuration, bone quality, and surgeon expertise. Continued research, including randomized controlled trials with longer follow-up, is recommended to further refine surgical strategies and optimize patient outcomes in distal humerus fracture management.

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