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Functional Outcomes of Complex Distal Humerus Fracture Treated by Open Reduction and Internal Fixation with Parallel Plate Technique

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ABSTRACT

Background: Distal humerus fractures, particularly AO/OTA type 13-C injuries, are complex intra-articular fractures that pose significant challenges in management. Open reduction and internal fixation (ORIF) using dual plating techniques, especially parallel plating, has been widely adopted to achieve stable fixation and early mobilization.
Objective: To evaluate the functional outcomes of complex distal humerus fractures treated with ORIF using the parallel plate technique.
Methods: This prospective observational study was conducted on 31 patients with distal humerus fractures at a tertiary care centre over a period of 18 months. Patients aged 20–60 years with AO/OTA type 13-C fractures were included. All patients underwent ORIF using the posterior approach with olecranon osteotomy and parallel plating. Functional outcomes were assessed using the Mayo Elbow Performance Score (MEPS). Patients were followed up clinically and radiologically for fracture union, range of motion, complications, and return to work.
Results: The mean age was 37.39 ± 8.96 years, with a male predominance (71%). Road traffic accidents were the most common mode of injury (45.2%). All fractures achieved union (100%) with a mean union time of 12.94 ± 1.97 weeks. The mean MEPS was 83.42 ± 11.62, with 83.9% of patients achieving excellent to good outcomes. The average range of motion was 100.32°. Heterotopic ossification was the most common complication (32.3%), while infection was minimal (3.2%). A majority of patients (87.1%) returned fully to work, and 90.3% were satisfied with the outcome.
Conclusion: ORIF with parallel plating is a reliable and effective method for managing complex distal humerus fractures, providing excellent union rates and satisfactory functional outcomes. Early mobilization and proper surgical technique contribute significantly to successful recovery.

Keywords*: Distal humerus fracture, parallel plating, ORIF, Mayo Elbow Performance Score, functional outcome, intra-articular fracture.*

INTRODUCTION

Fractures of the distal humerus are relatively uncommon, accounting for approximately 2–6% of all fractures and nearly one-third of elbow fractures in adults (1). These injuries are often complex, particularly when they involve the articular surface, and are frequently associated with comminution and displacement, making their management challenging (2).

The distal humerus has a unique bicolumnar structure, and restoration of both medial and lateral columns along with the articular congruity is essential for achieving good functional outcomes (3).

Distal humerus fractures typically occur due to high-energy trauma such as road traffic accidents in younger individuals, whereas low-energy falls are more common in the elderly population (4). The AO/OTA classification system is widely used for categorizing these fractures, with type 13-C fractures representing complete intra-articular injuries that require precise anatomical reduction and stable fixation (5).

Open reduction and internal fixation (ORIF) is considered the gold standard for the management of displaced intra-articular distal humerus fractures (6). The primary goals of treatment include anatomical reduction of the articular surface, stable fixation of fracture fragments, and early mobilization to prevent stiffness and ensure functional recovery (7). Various surgical approaches have been described, among which the posterior approach with olecranon osteotomy provides excellent visualization of the distal humerus articular surface (8).

Dual plating techniques, including orthogonal (90°–90°) and parallel plating, are commonly used for fixation. The parallel plating technique has gained increasing acceptance due to its biomechanical advantages, particularly in osteoporotic bone and comminuted fractures, as it provides enhanced stability and allows for early rehabilitation (9,10).
Despite advances in surgical techniques, complications such as heterotopic ossification, infection, implant failure, and elbow stiffness continue to pose challenges (11). Functional outcomes depend on multiple factors including fracture pattern, surgical technique, timing of intervention, and postoperative rehabilitation (12).

Therefore, the present study was undertaken to evaluate the functional outcomes of complex distal humerus fractures treated with open reduction and internal fixation using the parallel plate technique.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted in the Department of Orthopedics at BLDE (Deemed to be University), Shri B.M. Patil Medical College, Hospital and Research Centre, Vijayapura, Karnataka. The study was conducted over 18 months, from March 2024 to December 2025.

Study Population and Sample Size

A total of 31 patients with distal end humerus fractures were included in the study. The sample size was calculated using the formula:

$n = Z^2 \times p \times q / d^2$,

where p was taken as 94% based on previous studies, $q = 100 - p$, d as absolute precision of 10%, and confidence interval of 98%. This ensured adequate statistical power to assess functional outcomes.

Inclusion Criteria

1. Patients aged between 20 and 60 years
2. AO/OTA type 13-C fractures
3. Intercondylar fractures of distal humerus
4. Supracondylar fractures of distal humerus

Exclusion Criteria

1. Open distal humerus fractures
2. Associated fractures in the same limb
3. Associated neurovascular injuries

Data Collection Procedure

All patients presenting with distal humerus fractures to the emergency or outpatient department were screened. A detailed history including mechanism of injury, duration since injury, and associated conditions was obtained. General and systemic examination was performed to assess fitness for surgery.

Local examination included inspection, palpation, and neurovascular assessment of the affected limb. Range of motion of adjacent joints was also evaluated.

Radiological Assessment

All patients underwent:

1. Plain radiographs (anteroposterior and lateral views)
2. Computed tomography (CT) scan with 3D reconstruction

Fractures were classified according to the AO/OTA classification system, and only type C fractures were included.

Laboratory Investigations
Routine preoperative investigations included complete blood count, renal function tests, blood sugar levels, coagulation profile, serological tests (HIV, HBsAg, HCV), urine examination, and electrocardiogram. Additional tests were performed as required.

Preoperative Management
Patients were immobilized using an above-elbow posterior plaster slab. Limb elevation, analgesics, and cold compression were provided. Preoperative antibiotic prophylaxis (third-generation cephalosporin) was administered. Patients were kept nil per oral for at least 6 hours prior to surgery.

Surgical Technique
All surgeries were performed under general anesthesia or brachial plexus block. Patients were positioned in lateral decubitus position.

A posterior approach to the distal humerus was used. Olecranon osteotomy was performed in most cases to improve visualization. Fracture reduction was carried out anatomically, followed by fixation using the parallel plating technique with medial and lateral plates.

Articular fragments were reduced and temporarily fixed using K-wires or screws. Definitive fixation was achieved using locking and cortical screws. Olecranon osteotomy, when performed, was fixed using tension band wiring or plate fixation.

Postoperative Management
Postoperatively, the limb was immobilized in extension with a plaster slab and elevated. Antibiotics were continued for 48 hours, and analgesics were administered as required.

Early mobilization was initiated based on fixation stability. Physiotherapy included passive, active-assisted, and active range of motion exercises, followed by strengthening exercises after 6–8 weeks.

Follow-Up Protocol
Patients were followed up at 1 month, 3 months, and 6 months postoperatively. Clinical evaluation included pain, range of motion, and functional status. Radiographs were taken at each visit to assess fracture healing and implant position.

Fracture union was defined radiologically by bridging callus in at least three cortices and clinically by absence of tenderness.

Outcome Measures
Functional outcome was assessed using the Mayo Elbow Performance Score (MEPS), which evaluates:

1. Pain (45 points)
2. Range of motion (20 points)
3. Stability (10 points)
4. Daily function (25 points)

Scores were graded as:

1. Excellent: 90–100
2. Good: 75–89
3. Fair: 60–74
4. Poor: <60

Data Management and Statistical Analysis
Data were recorded in a structured proforma and entered into Microsoft Excel. Statistical analysis was performed using SPSS version 26.

Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Normality was assessed using Shapiro-Wilk/Kolmogorov-Smirnov tests. A p-value <0.05 was considered statistically significant.

Ethical Considerations
Ethical clearance was obtained from the Institutional Ethics Committee prior to study initiation. Written informed consent was obtained from all participants. The study adhered to the principles of the Declaration of Helsinki, and patient confidentiality was strictly maintained.

RESULTS AND OBSERVATIONS;

The present study was conducted in the Department of Orthopaedics at Shri B.M. Patil Medical College Hospital & Research Centre, Vijayapura, from March 2024 to December 2025, to determine the functional outcome of complex distal humerus fractures treated with open reduction and internal fixation using the parallel plate technique. A total of 301 patients were included in the study.

Demographic Characteristics

Table 1: Age and Gender Distribution of Study Population (N = 31)

Variable	Category	Frequency (n)	Percentage (%)
Age Group (years)	**20–30**	**7**	**22.6%**
	31–40	**13**	**41.9%**
	41–50	**8**	**25.8%**
	51–60	**3**	**9.7%**
Gender	**Male**	**22**	**71.0%**
	Female	**9**	**29.0%**
Total	**—**	**31**	**100%**

Mean Age ± SD: 37.39 ± 8.96 years

Occupational and Injury Characteristics

Table 2: Occupational and Injury Profile of Study Population (N = 31)

Variable	Category	Frequency (n)	Percentage (%)
Occupation	**Farmer**	**7**	**22.6%**
	Professional	**6**	**19.4%**
	Housewife	**5**	**16.1%**
	Retired	**5**	**16.1%**
	Student	**5**	**16.1%**
	Laborer	**3**	**9.7%**
Mode of Injury	**Road Traffic Accident (RTA)**	**14**	**45.2%**
	Fall at home	**10**	**32.3%**
	Fall from height	**7**	**22.6%**
Side Affected	**Right**	**17**	**54.8%**
	Left	**14**	**45.2%**
Total	**—**	**31**	**100%**

The occupational distribution showed that farmers (22.6%) constituted the largest group, followed by professionals (19.4%), while housewives, retired individuals, and students each accounted for 16.1%, indicating a wide occupational spread.'

Regarding injury mechanism, road traffic accidents (45.2%) were the most common cause, followed by falls at home (32.3%) and falls from height (22.6%), suggesting both high-energy and domestic trauma as major contributors.

The right side (54.8%) was more frequently affected than the left (45.2%), possibly reflecting limb dominance during injury events.

Fracture Characteristics

Table 3: AO Classification and Fracture Type Distribution (N = 31)

Variable	Category	Frequency (n)	Percentage (%)
AO Classification	**C1**	**1**	**3.2%**
	C2	**8**	**25.8%**
	C3	**22**	**71.0%**
Fracture Type	**Intercondylar**	**19**	**61.3%**
	Supracondylar–Intercondylar	**12**	**38.7%**
Total	**—**	**31**	**100%**

The AO classification revealed that the majority of fractures were type C3 (71.0%), indicating a predominance of highly complex intra-articular fractures. C2 fractures accounted for 25.8%, while only one case (3.2%) was classified as C1. Regarding fracture type, intercondylar fractures (61.3%) were more common than supracondylar–intercondylar fractures (38.7%), highlighting the prevalence of intra-articular involvement in the study population.

Surgical Management Details

Table 4: Surgical Management Profile (N = 31)

Variable	Category / Parameter	Frequency (n)	Percentage (%)	Value
Delay to Surgery	Mean ± SD	—	—	9.94 ± 4.79 days
	Range	—	—	2 – 17 days
Surgical Approach	Posterior with olecranon osteotomy	31	100.0%	—
Plate Type Used	Parallel anatomical plates	31	100.0%	—
Fixation Method	Parallel plating (medial and lateral)	31	100.0%	—
Olecranon Osteotomy Type	V-shaped	15	48.4%	—
	Chevron	9	29.0%	—
	Transverse	7	22.6%	—
Surgery Duration	Mean ± SD	—	—	160.32 ± 25.90 minutes
	Range	—	—	120 – 210 minutes

Follow-up, Union, and Functional Outcomes

Table 5: Combined Follow-up, Union, Range of Motion, and Functional Outcome Profile (N = 31)

Variable	Category / Parameter	Frequency (n)	Percentage (%)	Value
Follow-up Duration	Mean ± SD	—	—	32.16 ± 9.07 months
	Range	—	—	15 – 47 months
Union Status	United	31	100.0%	—
	Non-union	0	0.0%	—
Time to Union	Mean ± SD	—	—	12.94 ± 1.97 weeks
	Range	—	—	10 – 16 weeks
Range of Motion	Flexion	—	—	121.77 ± 17.91°
	Extension lag	—	—	21.45 ± 12.53°
	Total ROM	—	—	100.32 ± 24.32°
	Pronation	—	—	85.81 ± 4.30°
	Supination	—	—	85.65 ± 4.23°
MEPS Components	Pain score	—	—	33.87 ± 10.22
	ROM score	—	—	17.90 ± 2.51
	Stability score	—	—	10.00 ± 0.00
	Function score	—	—	19.45 ± 6.43
	Total MEPS	—	—	83.42 ± 11.62
MEPS Grading	Excellent (90–100)	10	32.3%	—
	Good (75–89)	16	51.6%	—
	Fair (60–74)	3	9.7%	—
	Poor (<60)	2	6.5%	—
Total	—	31	100%	—

Complications

Table 6: Combined Complication Profile (N = 31)

Variable	Category	Frequency (n)	Percentage (%)
Overall Complications	Heterotopic ossification	10	32.3%
	Infection	1	3.2%
	Nerve injury	0	0.0%
Brooker Classification (HO)	Grade 0	21	67.7%
	Grade 2	3	9.7%
	Grade 3	2	6.5%
	Grade 4	5	16.1%
Implant Removal	Yes	7	22.6%
	No	24	77.4%
Other Complications	None	28	90.3%
	HO resection with capsular release	2	6.5%
	Chondrolysis	1	3.2%
Total	—	31	100%

Heterotopic ossification was the most common complication, observed in 32.3% of patients, while infection occurred in only 3.2%, and no nerve injuries were reported.

According to the Brooker classification, the majority (67.7%) had no heterotopic ossification (Grade 0), whereas clinically significant HO (Grades 3 and 4) was seen in 22.6% of patients.

Implant removal was required in 22.6% of cases, while most patients (77.4%) did not require secondary surgery.

Overall, 90.3% of patients had no additional complications, with only a few requiring HO resection or developing chondrolysis, indicating an acceptable complication profile.

Functional Outcomes

Table 7: Combined Functional Outcome Profile (N = 31)

Variable	Category	Frequency (n)	Percentage (%)	p-value
Return to Work	**Full return**	**27**	**87.1%**	—
	Partial return	**4**	**12.9%**	—
Patient Satisfaction	**Satisfied**	**28**	**90.3%**	—
	Partially satisfied	**1**	**3.2%**	—
	Unsatisfied	**2**	**6.5%**	—
AO Classification vs MEPS Grade	**C1**	—	—	**0.842**
	C2	—	—	
	C3	—	—	
Fracture Type vs MEPS Grade	**Intercondylar**	—	—	**0.143**
	Supracondylar–intercondylar	—	—	
Mode of Injury vs MEPS Grade	**Fall at home**	—	—	**0.185**
	Fall from height	—	—	
	RTA	—	—	
Total	—	**31**	**100%**	—

The majority of patients showed excellent recovery, with 87.1% returning fully to work and 90.3% reporting satisfaction, indicating good functional restoration after surgery.

Statistical analysis revealed no significant association between functional outcomes and factors like AO classification, fracture type, or mode of injury, suggesting that the parallel plating technique provides consistently good results regardless of fracture complexity.

DISCUSSION

The present study assessed the functional outcomes of complex distal humerus fractures treated with ORIF using the parallel plating technique. The findings demonstrate that this method provides reliable fixation, excellent union rates, and satisfactory functional outcomes.

The mean age of patients in this study was 37.39 ± 8.96 years, with a predominance of males (71.0%). This is consistent with previous studies indicating that distal humerus fractures are more common in younger males due to high-energy trauma mechanisms (13,14). Road traffic accidents were the most frequent cause of injury, which aligns with earlier literature emphasizing trauma as a major etiological factor (15).

A majority of fractures in this study were classified as AO type C3 (71.0%), indicating a predominance of complex intra-articular fractures. Similar findings have been reported in previous studies, highlighting the surgical challenges associated with these injuries (16). Proper anatomical reduction and stable fixation are essential to restore joint congruity and function (17).

All patients were managed using a posterior approach with olecranon osteotomy and parallel plating. This approach allows excellent visualization of the articular surface and facilitates accurate reduction. Previous studies have supported the use of olecranon osteotomy for better exposure in complex fractures (18). The mean duration of surgery observed in this study is comparable to other reports, reflecting the technical demands of the procedure (19).

Fracture union was achieved in all patients (100%), with a mean union time of approximately 12.94 weeks. This is comparable with studies by McKee et al. and Sanchez-Sotelo et al., who reported high union rates with dual plating techniques (20,21). Stable fixation achieved through parallel plating allows early mobilization, which is crucial in preventing elbow stiffness.

The functional outcome assessed using the Mayo Elbow Performance Score (MEPS) showed a mean score of 83.42 ± 11.62, with 83.9% of patients achieving excellent to good results. These findings are consistent with previous studies demonstrating favorable outcomes with parallel plating (22,23). The range of motion achieved in this study falls within the functional arc required for activities of daily living (24).

Return to work is an important indicator of functional recovery. In this study, 87.1% of patients returned fully to work, which correlates with findings from earlier studies reporting good functional restoration following ORIF (25). Patient satisfaction was also high, further supporting the effectiveness of the treatment.

Heterotopic ossification was the most common complication, observed in 32.3% of patients. This is comparable to reported rates in the literature, which range from 10% to 49% following elbow surgery (26). Infection was minimal, and no nerve injuries were reported, indicating that the procedure is relatively safe when performed with proper technique.

No statistically significant association was found between functional outcomes and factors such as fracture type, AO classification, or mode of injury. This suggests that with appropriate surgical management and rehabilitation, good outcomes can be achieved regardless of fracture complexity. Similar observations have been made in previous studies (27).

Overall, the results of this study support the use of parallel plating as an effective method for managing complex distal humerus fractures, providing stable fixation, facilitating early mobilization, and resulting in satisfactory functional outcomes.

CONCLUSION

The present study demonstrates that open reduction and internal fixation using the parallel plating technique is an effective and reliable method for managing complex distal humerus fractures. It provides stable fixation, facilitates early mobilization, and results in high union rates with satisfactory functional outcomes.

The majority of patients achieved excellent to good functional results, with a high rate of return to work and overall patient satisfaction. Although complications such as heterotopic ossification were observed, they were manageable and did not significantly affect the final outcomes in most cases.

Therefore, parallel plating can be considered a preferred surgical technique for AO type 13-C distal humerus fractures, offering consistent and favorable results when combined with proper surgical technique and structured rehabilitation.

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