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Research Article

Evaluation of the Functional Outcome in Intra-Articular Distal Humerus Fractures Treated by Dual Plating

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Abstract

Background: The complex anatomy of the elbow joint, multiple displaced fragments, and intra-articular extension of the fracture make these cases challenging to treat and prone to complications. Several methods of limited internal fixation, such as Kirschner wires (K-wires), screw fixation, and single plates, have been described. However, these methods do not provide sufficient stability for early mobilization and often yield unpredictable results. The latest generation of pre-contoured anatomical compression locking distal humerus plate systems offers angular stability and rigid fixation for intra-articular distal humerus fractures. This study aims to evaluate the clinical outcomes of distal humerus fractures using dual plate fixation.

Methods: After ethics committee approval, this prospective observational study was conducted over a period of 26 months on 20 patients with intra-articular distal humerus fractures. Functional outcome was measured by using the Mayo Elbow Performance Score (MEPS) system. Radiological union was checked at regular intervals.

Results: Olecranon osteotomy (65%) showed better outcomes than the paratricipital approach (35%), with 60% of patients achieving excellent MEPS scores at 24 weeks. Radiographic union was observed in 60% of patients by 12-14 weeks, 25% by 16-18 weeks, and 15% by 18-20 weeks [mean ± standard deviation (SD) = 15.00 ± 2.83 weeks]. Mean range of motion (ROM) improved significantly from 65.83 ± 14.89 degrees at 6 weeks to 102.50 ± 15.88 degrees at 24 weeks ($P < 0.01$). Complications included one case each of wound infection, hardware protrusion, and stiffness, managed with antibiotics or physiotherapy.

Conclusion: The dual locking plating for intra-articular humerus fracture may be a better option in terms of stable and rigid fixation, functional outcome, and fewer complications.

Keywords: Distal Humeral Fractures; Intra-Articular Fractures; Elbow Joint

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Background

Distal humerus fractures in adults are uncommon, complex, and intra-articular, often involving both the medial and lateral columns. They account for approximately one-third of all elbow injuries (1). These fractures typically occur in younger individuals due to high-energy trauma, whereas in elderly women, they often result from low-energy trauma (2). When young individuals sustain such injuries, it adds to the socioeconomic burden on the community.

Nonoperative management of these fractures may lead to pseudoarthrosis with significant instability or a painful, stiff elbow (3). Due to the complex anatomy of the elbow joint, intra-articular extension, and frequent presence of multiple displaced fragments, these injuries are challenging to treat and are prone to complications (4). Restoring a painless, functional elbow after a distal humerus fracture requires anatomical reconstruction of the articular surfaces, restoration of the overall geometry of the distal humerus, and stable internal fixation to allow early and complete rehabilitation (5).

Traditionally, these fractures have been managed operatively using various surgical approaches that disrupt the extensor mechanism (6, 7). However, these approaches are often associated with complications such as delayed union, nonunion of the olecranon, triceps weakness, and osteotomy-related prominent implants (8). To address these complications, extensor mechanism-sparing approaches – such as triceps-splitting and triceps-reflecting techniques – have been introduced, allowing adequate bicondylar exposure while minimizing soft tissue disruption (9, 10).

Several methods of limited internal fixation, such as Kirschner wires (K-wires), screw fixation, and single plates, have been described. However, these methods do not provide sufficient stability required for early mobilization and often yield unpredictable results (11). Functional outcomes following open reduction and internal fixation (ORIF) of distal humerus fractures vary across studies. The primary treatment goal in comminuted distal humerus fractures is to restore a stable and functional range of motion (ROM) at the elbow. Therefore, it is essential to evaluate whether the chosen fixation method achieves both joint stability and mobility (12, 13).

Recent advances have introduced pre-contoured anatomical locking compression plate systems that provide angular stability and rigid fixation, especially beneficial for

intra-articular distal humerus fractures (14). These specially designed plating systems provide improved biomechanical properties and enhanced anchorage for these complex and unstable injuries (15). Due to these advantages, early mobilization and intensive rehabilitation are possible, potentially improving functional outcomes (16).

Currently, dual-plate fixation is considered the standard treatment for comminuted intra-articular fractures of the distal humerus (17, 18). This study aims to evaluate the clinical and functional outcomes of surgically treated intra-articular distal humerus fractures using dual plating techniques.

Methods

This prospective observational study was conducted over a period of 26 months (August 2020 to October 2022) at a tertiary center and included 20 patients with intra-articular distal humerus fractures. Institutional ethics committee (HBTMC/IEC/083-22/O/DT) approval was obtained, and informed consent was taken. Patient details were recorded from the clinical history proforma.

Inclusion Criteria

Patients were eligible for inclusion if they:

1. had intra-articular distal humerus fractures treated using dual plating,
2. were aged between 20 and 60 years, and
3. had open fractures classified as Gustilo-Anderson grade I.

Exclusion Criteria

Patients were excluded if they:

1. were younger than 20 or older than 60 years,
2. had open fractures classified as Gustilo-Anderson grade II or III,
3. presented with pathological fractures,
4. presented with extra-articular fractures,
5. sustained polytrauma, or
6. had fractures associated with distal neurovascular compromise.

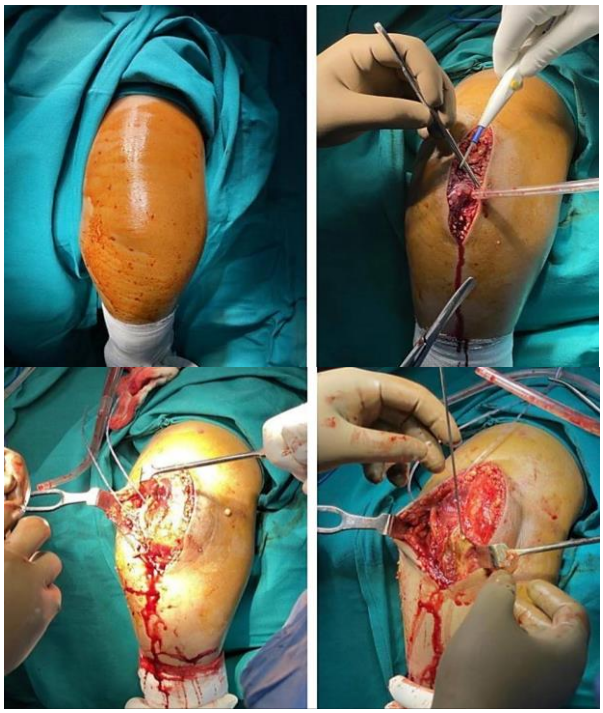

Figure 1. Incision, ulnar nerve isolation, and visualisation of fracture

Preoperative Evaluation: Preoperative evaluation included an assessment of general health and a thorough examination of the neurovascular status of the upper extremity. Radiographic evaluation consisted of anteroposterior (AP) and lateral views of the elbow, along with a computed tomography (CT) scan for detailed visualization.

Two surgical approaches were used: the olecranon osteotomy approach and the paratricipital approach.

The patient was positioned in the lateral decubitus position and prepared for surgery. A midline incision with a curve over the tip of the olecranon was made, followed by the development of full-thickness medial and lateral flaps. The ulnar nerve was dissected and protected. Laterally, the triceps was dissected off the lateral intermuscular septum, and the interval between the triceps and anconeus muscles was incised to expose the joint. The medial and lateral olecranon articular surfaces were visualized (Figure 1).

Before performing the osteotomy, predrilled holes were created for olecranon fixation. A distally oriented chevron osteotomy was made using an oscillating saw, directed toward the sulcus of the olecranon's articular surface. The osteotomy was completed using an osteotome. The triceps was then elevated along with the proximal olecranon, and the triceps musculature was carefully lifted off the humerus while preserving the periosteum (Figure 2).

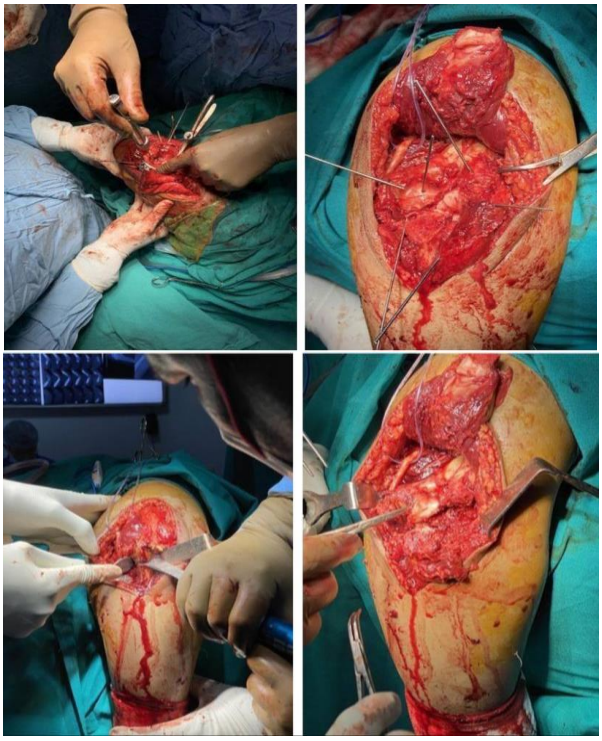

Figure 2. Olecranon osteotomy and temporary Kirschner wire (K-wire) fixation

In the paratricipital approach, the posterolateral humeral shaft was accessed by elevating the triceps and anconeus muscles from the posterior periosteum and retracting them medially. Medial paratricipital dissection and exposure of the posterior border of the intermuscular septum allowed visualization of the posteromedial aspect of the distal humerus. The triceps muscle was retracted medially and laterally to expose both columns (Figure 3).

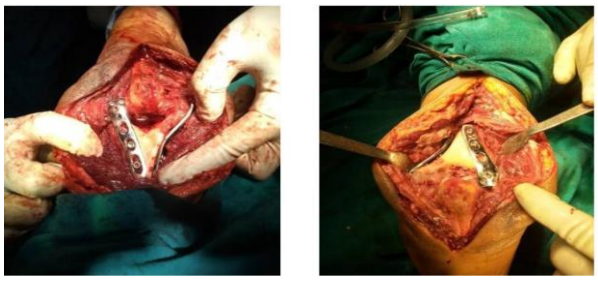

Figure 3. Paratricipital approach

Fracture edges were debrided to create clean surfaces. Threaded K-wires were used as joysticks to manipulate the medial and lateral condyles. If the articular fracture was simple, reduction would be achieved using joysticks and a Weber clamp, followed by provisional fixation with K-wires. The column with the better key was reduced first, followed by the opposite column.

For complex articular fractures, where either the medial or lateral condyle had a stable reduction key with the shaft, a 2-mm or 2.4-mm lag screw was used for provisional fixation, as its low profile did not interfere with plate positioning. The remaining condyle was then reconstructed and fixed to the shaft using dual plating. Headless screws were used for articular comminution fixation. Orthogonal plating was evaluated to ensure that no screws crossed the articular surface. The olecranon osteotomy was then repaired, and the incision was closed in layers over a drain.

Postoperative Protocol: Elbow ROM exercises were initiated between postoperative days 2 and 7, depending on the condition of the incision. Active-assisted and active ROM exercises were encouraged. At two weeks, sutures were removed, and the wound was examined for complications, which were recorded and managed accordingly.

Patients were followed up at 6, 16, and 24 weeks. At each follow-up visit, both clinical and radiological examinations were performed.

Outcome Assessment

Functional outcomes were assessed using the Mayo Elbow Performance Score (MEPS) (19) (Table 1), where:

- Scores > 90 indicated excellent results,
- Scores of 75-89 indicated good results,
- Scores of 60-74 were considered fair, and
- Scores < 60 were rated as poor.

Table 1. Mayo Elbow Performance Score (MEPS)

Function	Points	Definition
Pain	45	None (45)
		Mild (30)
		Moderate (15)
		Severe (0)
Motion	20	Arc > 100 degree (20)
		Arc: 50-100 degrees (15)
		Arc < 50 degree (5)
Stability	10	Stable (10)
		Moderate instability (5)
		Gross instability (0)
Function	25	Able toComb hair (5)
		Able to feed oneself (5)
		Perform hygiene tasks (5)
		Able to put on shirts (5)
		Able to put on shoes (5)

Radiological union was assessed by the presence of callus formation. Complications such as superficial infections, delayed wound healing, elbow stiffness, ulnar nerve neuropathy, heterotopic ossification, hardware prominence, clicking sounds during movement, and screw loosening were documented.

Statistical Analysis: Statistical analysis was performed using SPSS software (version 22, IBM Corporation, Armonk, NY, USA). The statistical tests (chi-square test) were conducted to calculate the P-value, with a $P < 0.05$ considered statistically significant.

Results

Most of the patients in the study were men, and the maximum number was from the age group of 35-45 years. The predominant mechanism of injury was road traffic accidents, accounting for 15 patients (75%), while the remaining five patients (25%) sustained fractures from falls from height. A total of 12 patients (60%) had fractures on the non-dominant hand, whereas the rest of the subjects had a fracture on the dominant side (40%).

Of the 20 patients, 13 (65%) underwent ORIF of the distal humerus using the olecranon osteotomy approach, while the remaining seven (35%) underwent surgery via the paratricipital approach. At the 24-week follow-up, among the 13 subjects treated with olecranon osteotomy, 10 (77%) had excellent outcomes and three (23%) had fair outcomes. In the paratricipital group, 2 (29%) patients achieved excellent outcomes and 5 (71%) had good outcomes (Table 2).

Table 2. Approaches and their outcomes

Approach	n (%)	MEPS (24 weeks)		
		Fair	Good	Excellent
		n (%)	n (%)	n (%)
Olecranon osteotomy	13 (65.00)	3 (23.08)	0 (0)	10 (76.92)
Paratricipital	7 (35.00)	0 (0)	5 (75.00)	2 (24.00)
Total	20 (100)			
Chi-square		8.14		
P-value		0.02*		

*Statistically significant
MEPS: Mayo Elbow Performance Score

It was observed that at six weeks postoperatively, MEPS grading was poor in 14 (70%) subjects. By 16 weeks, 12 patients (60%) had fair outcomes and at 24 weeks, 12 patients (60%) achieved excellent outcomes. The change in MEPS scores over time was statistically significant ($P = 0.003$) (Table 3).

Table 3. Functional outcome at different intervals using Mayo Elbow Performance Score (MEPS)

MEPS	At 6 weeks	At 16 weeks	At 24 weeks	P-value
	n (%)	n (%)	n (%)	
Excellent	0 (0)	3 (15)	12 (60)	0.003*
Good	3 (15)	5 (25)	3 (15)	
Fair	3 (15)	12 (60)	5 (25)	
Poor	14 (70)	0 (0)	0 (0)	

*Statistically significant
MEPS: Mayo Elbow Performance Score

Radiographic union was observed in 12 patients (60%) between 12 and 14 weeks, in five patients (25%) at 16-18 weeks, and in three patients (15%) at 18-20 weeks. The mean ± standard deviation (SD) of time taken for radiological union among the subjects was 15.00 ± 2.83 weeks (Table 4).

Table 4. Radiological union among the study subjects

Radiological union (week)	n (%)	P-value
12-14	12 (60)	0.021*
16-18	5 (25)	
18-20	3 (15)	
Mean ± SD	15.00 ± 2.83	

*Statistically significant
SD: Standard deviation

At 6 weeks, the mean ROM was 65.83 ± 14.89 degrees; at 16 weeks, it was 90.00 ± 12.61 degrees and at 24 weeks, it reached 102.50 ± 15.88 degrees. This improvement was statistically significant ($P < 0.01$) (Table 5).

Table 5. Mean comparison of range of motion (ROM) at different intervals

Intervals (week)	Minimum	Maximum	Mean ± SD	ANOVA test	P-value
0-6	40.00	90.00	65.83 ± 14.89	11.98	< 0.01*
6-16	70.00	110.00	90.00 ± 12.61		
16-24	70.00	120.00	102.50 ± 15.88		

*Statistically significant
ANOVA: Analysis of variance; SD: Standard deviation

Regarding complications, one patient (5%) developed a wound infection, which was treated with antibiotics, one patient (5%) experienced hardware protrusion, and one (5%) had stiffness that was managed with physiotherapy.

Discussion

Distal humerus fractures, being complex, were historically treated conservatively. Although distal humerus fractures are relatively uncommon, accounting for approximately 2-6 percent of all fractures, intra-articular fractures of the distal humerus pose significant operative challenges. These include the complex anatomy of the elbow, limited fixation area, and the presence of comminution and osteopenia of the articulating surfaces. As a result, these fractures have been recognized as complex articular injuries that are difficult to manage and often associated with poor outcomes and permanent disability. The primary objective of treatment is to achieve stable and accurate articular and bony reconstruction, allowing for early mobilization and rehabilitation, ultimately leading to a successful functional outcome.

The present study evaluated functional outcomes, radiological union, and postoperative complications in intra-articular distal humerus fractures treated with dual-locking plate fixation, using the MEPS as the primary assessment tool.

In this study, 13 patients (65%) underwent ORIF of the distal humerus using the olecranon osteotomy approach, while seven patients (35%) underwent surgery using the paratricipital approach. A study by Wilson et al. reported that 31 patients (33.3%) underwent the paratricipital approach, while 15 patients (26.8%) underwent olecranon osteotomy (20). Both paratricipital and olecranon osteotomy approaches and their comparative outcomes were also analyzed by Jeong et al. (21).

At 24 weeks post-surgery, functional outcomes showed that in the olecranon osteotomy group, three patients had fair outcomes, while 10 had excellent outcomes. In the paratricipital approach group, five patients had good outcomes, while two had excellent outcomes. In our study, the olecranon osteotomy technique was found to be superior to the paratricipital approach ($P < 0.05$), likely due to better visualization and direct reduction of the articular surface. A study by Singh et al. concluded that both the paratricipital and olecranon osteotomy approaches could be used interchangeably for distal humerus fractures, except for type C3 fractures, where the paratricipital approach yielded poorer outcomes (22). In another study, Singh et al. found better functional outcomes and improved visualization with the olecranon osteotomy technique (23). Elmadag et al. reported similar results (24).

The MEPS is an elbow-specific evaluation tool that assesses pain, mobility, stability, and function. At 6 weeks, MEPS grading was poor in 70% of subjects. By 16 weeks, MEPS grading improved to fair in 60% of subjects, and at 24 weeks, MEPS grading was excellent in 60% of subjects. The improvement in MEPS grading across different time intervals was statistically significant ($P = 0.003$). The progressive improvement in MEPS scores suggests better elbow mobilization, likely due to the rigid and stable fixation provided by dual-locking plates. A study by Park and Seok reported similar MEPS score improvements at regular postoperative intervals in distal humerus fractures treated with dual-locking plates (25). Likewise, Chouhan et al. also found comparable functional outcomes using the MEPS scoring system, further emphasizing the importance of dual-plating in achieving optimal results (26).

In the current study, radiographic union was observed in 60% of subjects within 12-14 weeks, while 15% of subjects achieved radiographic union within 18-20 weeks. The mean ± SD of time for radiological union was 15.00 ± 2.83 weeks. The study conducted by Chouhan et al. reported an average duration of radiological union of 14.0 ± 0.6 weeks in 60% of cases, 15.0 ± 0.4 weeks in 25% of cases, and 19.0 ± 0.5 weeks in 15% of cases (26). Similarly, a study by Asfuroğlu et al. on subjects undergoing ORIF with olecranon osteotomy found that radiological union was achieved within the first six postoperative months (27). Another study by Yadav et al. assessing the functional outcome of intra-articular distal humerus fracture fixation using a triceps-sparing paratricipital approach reported that all fractures united, with a mean time to union of 10.2 weeks (range: 8-14 weeks), without cases of nonunion or malunion (6). These findings suggest that radiological union was achieved in all subjects, highlighting the effectiveness of dual-locking plate fixation.

Achieving a good functional ROM with elbow stability is the primary goal in managing comminuted distal humerus fractures. The variation in ROM at different time intervals was statistically significant ($P = 0.005$). The mean ROM at 6, 16, and 24 weeks was 65.83 ± 14.89, 90.00 ± 12.61, and 102.50 ± 15.88, respectively. A study conducted by Kelkar and Rajput reported that the mean flexion ROM arc was 66.6 degrees at 2 months and 96.6 degrees at 6 months (28). Our findings indicate that substantial damage to the distal humerus often results in some limitations in motion, pain, weakness, and, in some cases, instability. Even minor irregularities in the joint surface of the elbow can cause functional loss, which can only be minimized through early and accurate open reduction with sufficiently rigid fixation to permit immediate mobilization.

In our study, postoperative complications were minimal. One subject developed a wound infection, one experienced hardware prominence, and another reported stiffness. A study by Savvidou et al. documented similar complications, including infection, hardware-related issues, stiffness, and ulnar neuropathy (29). Likewise, Kapil Mani et al. also reported comparable complications in their study (30).

The choice of surgical approach for distal humerus fractures is crucial for optimal exposure and fixation. The olecranon osteotomy approach offers excellent visualization of the articular surface and is commonly used in complex intra-articular fractures, especially AO type C fractures. However, it involves additional steps for osteotomy creation and fixation, with potential complications like nonunion or hardware irritation. The paratricipital (triceps-sparing) approach preserves the extensor mechanism, avoids osteotomy-related issues, and is preferred in less complex fractures or elderly patients with lower functional demands. Surgical decision-making depends on fracture pattern, surgeon experience, and patient-specific factors.

Although good functional outcomes were achieved in treating intra-articular distal humeral fractures, our study has certain limitations. These include the absence of a control or comparison group and a relatively small sample size. A multicenter randomized controlled trial (RCT) comparing dual-locking plate fixation with other fixation techniques would provide more comprehensive insights into this treatment approach.

Conclusion

Dual-locking plates provide a reliable and effective management option for distal humerus fractures. The biomechanical strength and rigidity of dual plates allow for early mobilization, which is critical in preventing joint stiffness and fixed deformities, thereby improving overall functional outcomes. Our findings suggest that dual-locking plate fixation may be an effective treatment modality for intra-articular distal humeral fractures.

Conflict of Interest

The authors declare no conflict of interest in this study.

Acknowledgements

None.

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