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ORIGINAL RESEARCH

A Study on Functional Outcome of Adult Type C Distal Humeral Fractures Treated with Bicolumnar Fixation

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ABSTRACT

Background: Distal humeral fractures in adults, particularly AO/OTA Type C fractures, are complex intra-articular injuries that demand precise anatomical reduction and stable fixation to restore elbow function. These fractures often result from high-energy trauma and pose challenges due to the distal humerus' intricate anatomy and limited bone stock. Bicolumnar plating, using either orthogonal or parallel configurations, has emerged as a reliable surgical method to achieve stable fixation and early mobilization, which are essential for optimal functional recovery and prevention of joint stiffness. **Method:** This prospective study included 28 adult patients with AO/OTA Type C distal humeral fractures treated with open reduction and internal fixation using bicolumnar plating. Patients were operated on using either orthogonal or parallel plating techniques via olecranon osteotomy or triceps-sparing approaches. Ulnar nerve transposition and olecranon repair techniques were recorded. Postoperative care included standardized physiotherapy. Functional outcomes were assessed using the Mayo Elbow Performance Score (MEPS), and radiological union, range of motion, and complications were documented over a one-year follow-up period. **Result:** In this study of 28 patients with Type C distal humeral fractures, the mean age was 45.2 years, with males comprising 64.3%. Road traffic accidents were the leading cause (64.3%). Most patients underwent olecranon osteotomy (82.1%) with orthogonal plating (64.3%). Functional outcomes were favorable, with a mean MEPS of 88.6; 57.1% had excellent results. Radiological union occurred in 14.8 weeks on average. Complications included ulnar neuropathy (21.4%) and hardware irritation (14.3%). C1 fractures and orthogonal plating showed better functional outcomes. **Conclusion:** We found that anatomical reconstruction and rigid bicolumnar fixation in adult distal humerus Type C fractures yields favourable outcomes. Orthogonal plating may offer advantages in elbow mobility, however, both configurations are effective when applied appropriately. Fracture complexity can impact prognosis significantly; therefore, emphasis should be on individualized surgical planning and execution.

Keywords: Type C Distal Humeral Fractures, Bicolumnar Screws,Olecranon Osteotomy

INTRODUCTION

Distal humerus fracture is an uncommon fracture accounting for 2% of all fractures and about one-third of humeral fractures [1]. Among the humeral fractures, the intra-articular Type C fractures based on the AO/OTA classification are the most complex, involving both columns of the distal humerus and the articular surface [2]. Several challenges exist during the treatment of these injuries because of complex fracture patterns and reduced bone volume affecting the proximity of nervous and vascular structures, while needing successful repair of stability and elbow functionality.Previous practices of non-surgical fracture treatment led to poor results, including elbow stiffness along with malunion and impaired functionality [3]. Open reduction and internal fixation (ORIF) has achieved status as the primary method to treat intra-articular distal humeral fractures in physiologically active adults [4]. The main surgical goals include restoring the anatomy of the articular surface and creating solid fixation in both columns and allowing immediate elbow movement and function recovery [5].

Bicolumnar fixation, which stabilizes the medial and lateral columns of the distal humerus, is critical for achieving biomechanical stability of these fractures [6]. The common techniques include orthogonal (90–90°) and parallel plating configurations and these

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techniques have shown comparable results in terms of union and functions [7, 8] However, the accurate orientation and type of screw fixation is important particularly the placement of screws to engage both columns will result in better long-term functional outcomes. Recently the use of bicolumnar screws that goes through both medial and lateral columns helps to augment fixation and stability. This approach also enhances the interfragmentary compression and resists torsional forces in cases where the fractures involve osteoporotic bone or comminuted fractures [9].

Bicolumnar screw placement together with anatomically contoured plates demonstrates improved reduction maintenance and early mobility along with reduced risk of hardware failure and non-union [10]. Locking compression plates combined with bicolumnar screws enhance treatment results in elderly patients by providing stable angular fixation during poor bone quality situations [11]. After performing complex fracture fixation, surgeons use the Mayo Elbow Performance Score (MEPS) evaluation tool to assess functional outcomes by assessing pain and stability as well as motion and functional ability [12]. Early joint movement following surgery becomes vital since elbow stiffness develops frequently after operations. Ulnar nerve dysfunction alongside heterotopic ossification and implant irritation represent persistent issues that occur after some advanced surgical procedures [13]. Since there is lack of consensus regarding the optimal surgical approach and fixation for Type C distal humeral fractures we decided to conducted this study to evaluate the functional outcomes of adult patients with AO/OTA Type C distal humeral fractures treated with ORIF using bicolumnar screw fixation.

MATERIALS AND METHODS

This prospective study was conducted in the Department of Orthopedics, Prathima Institute of Medical Sciences, Naganoor, Karimnagar, Telangana. Institutional Ethical approval was obtained for the study. Written consent was obtained from all the participants of the study after explaining the nature of the study and possible outcomes in the vernacular language.

Inclusion Criteria

1. Diagnosed with AO/OTA Type C distal humeral fractures
2. Aged 18 years and above
3. Underwent open reduction and internal fixation (ORIF) with bicolumnar screw fixation using dual plating technique
4. Presented within 2 weeks of injury

Exclusion Criteria

1. Open fractures classified as Gustilo-Anderson grade III
2. Pathological fractures
3. Polytrauma patients with significant concomitant upper limb injuries
4. Previous surgery or deformity around the elbow
5. Patients unwilling or unable to comply with follow-up protocols

Surgical Technique in brief: All surgeries were performed under general or regional anesthesia in a sterile operative setting. A standard posterior midline approach with olecranon osteotomy was used in most cases to provide adequate visualization of the articular surface. The fracture was anatomically reduced and temporarily stabilized with K-wires or clamps. Definitive fixation was achieved using dual platingeither parallel or orthogonal configurationalong with bicolumnar screw placement. Plates were pre-contoured distal humeral locking compression plates (LCPs), and all screws in the distal fragment were directed to gain purchase in both medial and lateral columns wherever feasible. The olecranon osteotomy was repaired using tension band wiring or cancellous screws as required.Ulnar nerve was routinely identified, decompressed, and transposed anteriorly in selected cases to prevent postoperative neuropathy.

Postoperative Management: All patients were given a posterior splint with the elbow in 90° flexion for 7–10 days postoperatively. Active-assisted range of motion exercises were started thereafter, depending on patient compliance and stability of fixation. Patients were followed up at 2 weeks, 6 weeks, 3 months, 6 months, and 12 months postoperatively. Radiographic assessment of union and complications was conducted at each visit.

Outcome Measures: The primary outcome was functional recovery, assessed using the Mayo Elbow Performance Score (MEPS) at final follow-up. Secondary outcomes included:Time to radiological union (defined as presence of bridging callus in 3 cortices). Incidence of complications: non-union, infection, implant failure, and ulnar neuropathy. Range of motion at the elbow joint (flexion-extension arc and rotation)

Statistical Analysis: All the available data were refined, segregated, and uploaded to an MS Excel spreadsheet and analyzed by SPSS version 22 in Windows format. The continuous variables were represented as mean, standard deviation, frequency, and percentages. The categorical variables were analyzed by Chi-square test, and the p-value of <0.05 was considered statistically significant.

RESULTS

A total of n=28 cases were included in the study based on the inclusion and exclusion criteria. The baseline profile of the cases is depicted in Table 1. The mean age of the cohort was 45.2 ± 12.8 years, indicating that middle-aged adults were the predominant group affected. Males predominated by 64.3% of all cases, suggesting greater occupational or outdoor activity risk. The most common mechanism of injury was road traffic accidents (64.3%), followed by falls (25.0%)

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and direct trauma (10.7%), reflecting the high-energy nature commonly associated with distal humeral fractures. Fractures were classified according to the AO/OTA system, with Type C2 being the most common (42.9%), followed by Type C1 (35.7%) and C3 (21.4%), indicating a range of fracture complexity.

Table 1: Demographic and Clinical Characteristics (n=28)

Parameter	Value
Age (years)	45.2 ± 12.8 (Mean ± SD)
Gender	
Male	18 (64.3%)
Female	10 (35.7%)
Mechanism of Injury	
RTA	18 (64.3%),
Fall	7 (25.0%)
Direct Trauma	3 (10.7%)
AO/OTA Fracture Type	
C1	10 (35.7%)
C2	12 (42.9%)
C3	6 (21.4%)

The details of the surgical procedures in the cases of the study are described in Table 2. The olecranon osteotomy approach was used in 82.1% of cases because of its value in providing excellent articular visualization for complex fractures. A triceps-sparing approach was used in the remaining 17.9% because of simpler fracture configurations. Orthogonal plating was more commonly employed (64.3%) than parallel plating (35.7%) because of a preference for columnar biomechanical stability. Ulnar nerve transposition was performed in 53.6% of cases to reduce postoperative neuropathy risk, indicating surgeon awareness of nerve protection in elbow surgeries. For olecranon osteotomy repair, tension band wiring was used in 71.4% of cases, with cancellous screw fixation used in 28.6%, reflecting varied techniques based on bone quality and surgeon preference.

Table 2: Surgical Details of the cases included in the study

Parameter	Number (%)
Surgical Approach	
Olecranon osteotomy	23 (82.1%),
Triceps sparing	5 (17.9%)
Fixation Configuration	
Orthogonal Plating	18 (64.396),
Parallel Plating	10 (35.796)
Ulnar Nerve Transposition	
Yes	15 (53.6%),
No	13 (46.4%)
Olecranon Repair	
Tension Band Wiring	20 (71.4%),
Cancellous Screw	8 (28.6%)

Table 3: Functional Outcomes (Mayo Elbow Performance Score, MEPS). At final follow-up, 57.1% of patients achieved excellent outcomes (mean MEPS 94.5 ± 3.2), while 32.1% had good outcomes, and only a minority showed fair (7.1%) or poor (3.6%) results. The overall average MEPS was 88.6 ± 9.4, indicating high levels of patient satisfaction and functional recovery in most cases. These results show the effectiveness of anatomical reduction and rigid fixation with bicolumnar screws in restoring elbow function following complex distal humeral fractures. The results also highlight the importance of early mobilization and rehabilitation in improving long-term outcomes.

Table 3: Functional Outcomes (Mayo Elbow Performance Score, MEPS)

MEPS Category	Number (%)	Mean MEPS ± SD
Excellent (290)	16 (57.1%)	94.5 ± 3.2
Good (75-89)	9 (32.1%)	82.3 ± 4.1
Fair (60-74)	2 (7.1%)	68.0 ± 5.6
Poor (<60)	1 (3.6%)	55.0
Overall	-	88.6 ± 9.4

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Table 4 summarizes the healing and range of motion data postoperatively. A critical analysis of this table shows that the mean time to radiological union was 14.8 ± 2.6 weeks (range: 12–20 weeks), which aligns with accepted timelines for distal humeral fracture healing. The average elbow flexion-extension arc was 112.5°, with a mean flexion of 125.4° and an extension loss of 12.9°, showing functional range despite some residual stiffness. Pronation-supination arc averaged 152.7°, which is near normal, suggesting forearm rotation is well-preserved post-surgery. Overall, these results show a satisfactory bony union and functional restoration in most patients following surgical fixation with bicolumnar screws.

Table 4: Radiological and Clinical Outcomes

Outcome	Value
Time to Union (weeks)	14.8 ± 2.6 (Range: 12-20)
Flexion-Extension Arc	112.5° ± 18.3°
Flexion	125.4° ± 12.8°
Extension Loss	12.9° ± 6.5°
Pronation-Supination Arc	152.7° ± 22.1°

Table 5 depicts the complications encountered during follow-up in the cases of the study. Ulnar neuropathy was the most common (21.4%) but resolved spontaneously in all affected patients, emphasizing the need for careful intraoperative handling of the nerve. Hardware irritation occurred in 14.3% of patients and was managed conservatively, often without the need for implant removal. Superficial infections were found in 7.1% of cases, and they were managed successfully with antibiotics. Only one patient (3.6%) developed non-union, necessitating revision surgery. These complication rates in our study are relatively low and suggest that the bicolumnar fixation strategy provides a stable construct and promotes healing with acceptable morbidity.

Table 5: Postoperative Complications

Complication	Number (%)	Management
Ulnar Neuropathy	6 (21.4%)	Resolved spontaneously
Hardware Irritation	4 (14.396)	Conservative
Superficial Infection	2 (7.1%)	Antibiotics
Non-Union	1 (3.6%)	Revision surgery

Comparative analysis of fracture type is given in Table 6. The results show the outcomes based on AO/OTA fracture classification. Type C1 fractures had the best functional outcomes. The mean MEPS of 92.3 and a flexion-extension arc of 120° indicate less complexity and better recovery. Similarly, Type C2 fractures showed moderate outcomes (MEPS 87.5), while C3 fractures had the poorest performance (MEPS 81.5, ROM 98.3°). This shows that there are challenges in management because of articular involvement and comminution. The difference in MEPS and ROM was statistically significant (p=0.02 and p=0.03), while union times showed a non-significant trend toward longer healing in more complex fractures. These findings highlight how increasing fracture complexity correlates with diminished outcomes.

Table 6: Comparative Analysis by Fracture Type

Parameter	Cl (n=10)	Q (E 12)	C3 (n=6)	p-value
MEPS	92.3 ± 62	87.5 ± 8.1	81.5 ± 10.1	0.02*
Time to Union (weeks)	13.5 ± 1.8	14.9 ± 2.4	16.2 ± 3.0	0.08
ROM (Flexion-Extension)	120.00 ± 10.50	115.00 ± 15.20	98.30 ± 20.70	0.03*

*Significant

Table 7 shows the assessment of outcomes based on the fixation method used. Orthogonal plating (n=18) cases resulted in a higher mean MEPS (90.1 ± 8.5) and superior flexion-extension range of motion (118.2° ± 15.6°) compared to parallel plating (n=10) cases, which had a lower MEPS (85.2 ± 10.3) and ROM (104.8° ± 20.1°). The difference in range of motion was statistically significant (p=0.04). This favors orthogonal construction for improved mobility. However, differences in MEPS and complication rates were not statistically significant (p=0.15 and p=0.45, respectively). These results show that while both configurations are effective, orthogonal plating may offer a slight edge in functional elbow mobility postoperatively.

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Table 7: Fixation Configuration vs. Outcomes			
Parameter	Orthogonal (n= 18)	Parallel (n=10)	p-value
MEPS	90.1 ± 8.5	85.2 ± 10.3	0.15
ROM (Flexion-Extension)	118.2° ± 15.6°	104.8° ± 20.1°	0.04*
Complication Rate	5 (27.8%)	4 (40.0%)	0.45

*Significant

DISCUSSION

This study was conducted on adult patients with AO/OTA Type C distal humerus fractures treated with bicolumnar fixation using orthogonal or parallel plating techniques to evaluate the functional and radiological outcomes. Distal humerus fractures, especially complex intra-articular types, present challenging conditions because of their complex anatomy, together with the requirement for secure fixation while facing increased risk of complications. Treating these injuries aims to achieve elbow function by using stable anatomic reductions combined with rigid internal fixation, followed by early mobilization protocols [14]. In this study we evaluated n=28 cases of distal humerus fractures and the mean age of the cohort was 45.2 years with predominantly involving males (64.3%), similar findings have been reported in other studies where middle-aged patients and males are commonly involved in this kind of injuries due to high-energy trauma such as road traffic accidents (64.3%) [15, 16]. The present study showed that patients with Type C2 fractures (42.9%) outnumbered those with C1 (35.7%) and C3 (21.4%). Type C3 fractures represent the most comminuted and technically demanding fractures, usually associated with poorer outcomes due to difficulty in achieving congruent articular surface reconstruction [17]. Our study showed that C3 fracture patients demonstrated the minimum scores in both MEPS (81.5) and flexion-extension arc measurements (98.3°), which proved statistically inferior to C1 and C2 groups (p=0.02 and p=0.03). These findings were in concordance with studies of Ring et al. [18] and Athwal et al.'s [19] findings showing functional outcomes worsen as the fracture complexity escalates. In the current study, most patients (82.1%) underwent surgery via the olecranon osteotomy approach. This approach offers excellent exposure of the distal articular surface; however, it is associated with complications such as hardware irritation and delayed healing [20]. Tension band wiring served as the commonly used technique for fixing olecranon fractures during our study. The approach led to ulnar neuropathy in 21.4% of patients, and hardware irritation affected 14.3%, but both conditions resolved without surgical intervention. The low incidence of superficial infection (7.1%) underscored both the sound surgical technique execution and postoperative follow-ups.

Orthogonal plating methods were used more frequently (64.3%) than parallel plating methods (35.7%) because surgeons were familiar with the technique and considered its biomechanical advantages. The results indicate that orthogonal plating achieved slightly better mean MEPS scores (90.1 vs. 85.2) while also producing significantly improved flexion-extension arc measurements (118.2° vs. 104.8°; p=0.04). The findings match those of previous biomechanical studies by Self et al. [21] and Korner et al. [22] because orthogonal plating demonstrates better resistance to varus forces while enabling greater functional range. There were no statistically significant differences between outcomes for MEPS (p=0.15) and complications (p=0.45) when comparing constructs under appropriate application.In this study, we found that the overall union rate was high, with a mean union time of 14.8 weeks and only one case requiring non-union revision. Functional outcomes showed 87.1% of patients achieving excellent MEPS scores, while one patient was in the poor category. These results are in agreement with other large-scale reviews of Sodergard et al. [23] and Schwartz et al. [24], who report similar outcome distributions with bicolumnar fixation techniques. The postoperative range of motion was satisfactory for most of the cases, with the mean flexion of 125.4°, extension lag of 12.9°, and the pronation-supination arc of 152.7°. Our early mobilization, achieved by stable fixation and application of appropriate physiotherapy, was involved in these outcomes. As shown by O'Driscoll [25], achieving early range of motion is essential to minimizing elbow stiffness, which is very common in these types of injuries.

CONCLUSION

In conclusion, we found that anatomical reconstruction and rigid bicolumnar fixation in adult distal humerus Type C fractures yields favourable outcomes. Orthogonal plating may offer advantages in elbow mobility, however, both configurations are effective when applied appropriately. Fracture complexity can impact prognosis significantly; therefore, emphasis should be on individualized surgical planning and execution. Complications such as neuropathy and hardware irritation are commonly encountered; however, they are generally manageable and do not significantly compromise functional recovery.

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