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Prospective study to evaluate the functional and radiological outcome of intra-articular fractures of distal end humerus fixed with dual plating

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ABSTRACT

Background: Distal humerus fractures, however rare in adults, pose significant surgical problems due to their intricate anatomy and articular involvement. For functional motion, AO type C intra-articular fractures need stable fixation. Despite scant Indian evidence, dual-plate osteosynthesis is commonly used.
Methods: A prospective observational study at Tata Main Hospital, Jamshedpur, patients with AO type C distal humerus fractures. Each was open reduced and internally fixed with dual plating (orthogonal or parallel). Radiological combination was described by joining three cortices and functional outcomes were measured by the Mayo Elbow Performance Score (MEPS). After the Shapiro–Wilk test showed that the data were normal, statistical analysis was done.
Results: Mean age: 49.5±12.5 years and 51.6% of them were women. Falls were the main cause of most AO type C2 fractures (51.6%). MEPS was much higher in people younger than 60 than in people older than 60 (p=0.016). Mean MEPS was highest for C1 fractures and lowest for C3 fractures (p=0.068), but there was no link between the two that was significant. As many as 80.6% of the results were good or excellent.
Conclusions: Dual-plate fixation effectively reduces AO type C distal humerus fractures, enabling early mobilization and improved function. Younger age improves prognosis, but fracture complexity does not. Prospective design and standardized evaluation are study strengths, but small sample size and restricted follow-up are weaknesses. Multicentric trials should be larger.

Keywords: AO type C, Dual plating, Distal humerus fractures, Mayo elbow performance score, Radiological union

INTRODUCTION

Fractures of the distal humerus, comprising less than 2% of all adult fractures, represent a substantial category of humeral injuries, including about one-third of such instances.[1,2] These injuries exhibit a bimodal epidemiological character, resulting from high-energy trauma in younger individuals and low-energy falls in the elderly, often worsened by osteoporotic bone quality.[3-6] Intra-articular fractures of the distal humerus, designated as AO type 13C, present significant challenges in orthopaedic trauma surgery due to the complex osseous structure of the elbow, the small size of the articular fragments, comminution and diminished structural integrity in elderly patients. Conservative methods, such as functional bracing, have been replaced mainly for displaced intra-articular fractures, as they frequently fail to preserve anatomical alignment and require extended immobilization, leading to incapacitating elbow stiffness and functional impairment.[5,6] The primary goals of surgical care are to restore the normal alignment of the articular surface, re-establish bicortical stability and

enable early mobilization, hence maintaining the functional range of motion.[7,8] The olecranon osteotomy provides exceptional access to the articular surface, enabling precise repair. Nonetheless, its implementation has intrinsic hazards, such as delayed or non-union at the osteotomy site, diminished biceps strength, wound problems and hardware-associated morbidity.[9-13] Other surgical procedures such as triceps-sparing and Para tricipital techniques have been recommended to reduce extension mechanism disruption.[14-19]

Biomechanical evidence highlights the superiority of dual-plate fixation in orthogonal or parallel configurations for attaining rigid stabilization in complex distal humeral fracture patterns.[20-23] This construct facilitates secure stabilization of small distal pieces, promotes early functional rehabilitation and diminishes the risk of fixation failure. However, the procedure presents obstacles, especially regarding the degree of soft-tissue dissection, extended operational time and risk of infection.

Although worldwide literature provides extensive assessments of dual-plating procedures for intra-articular distal humerus fractures, current data from the Indian subcontinent is limited. This is among the only prospective Indian studies that systematically assess both functional and radiological results of AO type C fractures utilizing standardized MEPS scoring. Present study aims to assess the functional and radiological outcomes of AO type C intra-articular distal humerus fractures treated with dual-plate fixation, utilizing the MEPS as the primary measure of functional recovery.[3,7,23-26]

METHODS

Study design

This prospective observational study was carried out in an Indian tertiary care hospital, India, during a 14-month duration from June 2022 to July 2023. The study population consisted of patients diagnosed with intra-articular distal humerus fractures categorized as AO type C. Patients were enrolled sequentially upon satisfying the established eligibility criteria. The study included skeletally mature adult patients (≥18 years) of both sexes with AO type C intra-articular distal humerus fractures, who were medically suitable for surgery and agreed to participate.

Patients with undisplaced fractures, AO type A or B fracture patterns, Grade II or III open fractures, pathological or severely broken bones unsuitable for fixation and those with concomitant neurovascular damage or compartment syndrome were excluded.

Individuals who were refusing to pursue surgical intervention or subsequent follow-up were likewise eliminated. Patients were followed after 2 weeks, 6 weeks, 12 weeks, 16 weeks and 6 months. During each visit, a clinical examination, radiographs and MEPS score were conducted. All cases received surgical fixation utilizing standard principles applied to the fracture type and patient state, providing anatomical reduction, stable fixation and early mobilization in line with published procedures.

Study outcome

The primary outcome of this study was to evaluate the functional recovery of the elbow joint, measured by the MEPS, a recognized composite metric that includes pain, joint stability, range of motion and the ability to perform daily activities. Concurrently, radiological consolidation which is defined as osseous callus that covers at least three cortices in orthogonal projections was included as a co-primary outcome factor. Secondary Outcome included the monitoring of preoperative and postoperative complications, including as deep or superficial infection, mechanical implant failure, postoperative stiffness and neuropathic problems involving the ulnar nerve. Furthermore, outcome variability for chronological age categories and fracture subtypes (C1, C2, C3) was methodically examined. These metrics provided a complete framework to evaluate both the functional efficacy and radio morphological integrity after dual-plate fixation of AO type C distal humeral fractures.

Surgical techniques

All patients received open reduction and internal fixation utilizing a dual-plate design (orthogonal or parallel configuration) under general or regional anesthesia. Exposure was obtained using the standard posterior technique utilizing olecranon osteotomy. The ulnar nerve was recognized and safeguarded. The articular surface was initially anatomically reduced, followed by both columns' fixation. The osteotomy has been repaired via tension-band wiring. Active-assisted and passive mobilization commenced on postoperative day one.

Statistical examination

Data were compiled in Microsoft Excel and analyzed using SPSS software version 24.0 (IBM Corp., USA). Prior to inferential testing, data normality was evaluated using the Shapiro–Wilk test to determine the suitability of parametric methods. Continuous variables (e.g., age, MEPS scores) were summarized as mean±standard deviation (SD).

Where data demonstrated normal distribution, comparisons were performed using one-way ANOVA and the Independent Samples t-test to examine mean differences across groups. Categorical variables (e.g., sex, fracture type, MEPS grading) were expressed as absolute frequencies and percentages and analyzed using the Chi-square test or Fisher's exact test, depending on distributional assumptions and expected cell counts. Statistical significance will be determined at 5% level of significance.

RESULTS

Patient demographics and injury characteristics

A study of 31 patients, with a mean age of 49.5±12.5 years, found that middle-aged and older persons were most impacted. Women (51.6%) outweighed men (48.4%), indicating a near-equal sex distribution. Injury rates were slightly higher on the left (54.8%) than right (45.2%). In dominant (48.4%) and non-dominant (51.6%) limbs, hand injuries were practically equal. This cohort's even demographic and laterality distribution shows that neither sex nor side dominance affected injury risk. The profile shows that distal humerus fractures are not highly predisposed to gender, side or hand dominance, limiting their potential confounding effects in outcome evaluation.

Figure 1: Intraoperative photograph demonstrating dual plate fixation of the distal humerus.

Figure 2: Intraoperative C-arm fluoroscopic image demonstrating dual plate fixation of the distal humerus.

Figure 3: Postoperative lateral view X-ray showing distal humerus fixation with dual plating.

Fracture pattern distribution and mechanism of injury

Most of the fractures were of the AO type C2 variety (51.6%), followed by C1 fractures (29%) and C3 fractures (19.4%). The mechanism of injury was roughly equally distributed between high-energy trauma patterns and low-energy trauma structures, with falls accounting for 51.6% of injuries and road traffic incidents accounting for 48.4% of injuries. Due to the low incidence of associated injuries (12.9%), it can be predicted that most cases involved isolated elbow damage, allowing for targeted rehabilitation without considerable interference from more widespread systemic diseases.

Functional outcomes (MEPS) by age group and fracture subtype

As indicated by the statistically significant difference (p=0.016), the mean MEPS was found to be significantly higher in patients under the age of 60 (84.37±10.86) compared to those 60 years and over (72.85±8.59). This suggests that younger age is a favorable prognostic factor.

In addition to the fact that the differences between fracture types (C1, C2 and C3) did not reach the level of statistical significance (p=0.068), a pattern was found in which C1 fractures shown the greatest mean MEPS and C3 fractures showed the lowest. It has been shown that stable fixation and systematic rehabilitation can provide satisfactory outcomes across all fracture subtypes, as evidenced by the fact that 80.6% of patients obtained good to outstanding results.

Table 1: Baseline demographic and injury profile.

Variables	Frequency (%)
Age (in years)	
21-40	8 (25.8)
41-70	23 (74.2)
Mean age	49.5±12.5

Continued.

Variables	Frequency (%)
Gender	
Male	15 (48.4)
Female	16 (51.6)
Laterality	
Right elbow	14 (45.2)
Left elbow	17 (54.8)
Hand dominance	
Dominant	15 (48.4)
Non-dominant	16 (51.6)

Table 2: Fracture classification and injury characteristics.

Variables	Frequency (%)
AO fracture type	
C1	9 (29.0)
C2	16 (51.6)
C3	6 (19.4)
Mode of injury	
Fall	16 (51.6)
Road traffic accident	15 (48.4)
Associated injuries	
Chest injury	1 (3.2)
Head injury	1 (3.2)
Ipsilateral distal end radius	2 (6.5)
fracture	27 (87.1)
None	

Table 3: MEPS by age group and fracture type one-way ANOVA comparing fracture types.

Variable	n	MEPS Mean±SD (Range)	P value
Age group (in years)			
<60	24	84.37±10.86	0.016
≥60	7	72.85±8.59	
Fracture type (AO)			
C1	9	87.77±9.71 (70–100)	0.068
C2	16	81.25±10.56 (65–100)	
C3	6	74.16±12.41 (55–90)	

DISCUSSION

This prospective study included 31 skeletally mature people with AO type C distal humerus fractures. The demographic analysis indicated that the average age of the patients was 49.5 years, with a predominant 74.2% of patients within the age group of 41–70 years. The findings of Korner et al indicate that distal humerus fractures in adults predominantly affect individuals in middle age and older.[21] This occurs as a result of high-energy trauma in younger individuals and low-energy accidents in elderly people. The nearly equal proportion of males and females (48.4% males and 51.6% females) reflects the findings of Robinson et al identified no significant gender disparity in frequency across both forms of damage examined.[27] Similarly to Ali et al who discovered that the non-dominant limb sustains more frequent injuries during protective falls, the lateral pattern indicated a little majority of left-sided injuries (54.8).[27] This discovery aligns with the conclusions of the previously listed researchers. The injury mechanism in the study was evenly divided between low-energy falls (51.6%) and high-energy road traffic events (48.4%). Sanchez-Sotelo et al observed a bimodal structure wherein younger patients experienced high-energy trauma, whereas elderly patients suffered low-energy fractures.[28] The existence of osteoporotic bone in elderly persons requires the implementation of sturdy dual-plate constructs and careful management of soft tissues. This dual mechanism impacts the selection of fixation. The classification of fractures determined that AO type C2 fractures were the most prevalent, comprising 51.6% of all fractures, followed by

C1 fractures at 29% and C3 fractures at 19.4%. The percentages align with the findings of Athwal et al, (2009), which indicated that C2 fractures were the predominant injury type in mixed-mechanism injury series.[29] The restricted representation of extreme high-energy trauma cases, which often exhibit greater comminution, could be to blame for the significantly decreased occurrence of C3 fractures in our sample. Shin et al noted that C3 fractures were associated with a higher risk for postoperative stiffness and a more challenging fixation procedure. This represents an essential discovery.[30]

The analysis of functional outcomes utilizing the MEPS indicated that patients younger than 60 attained significantly higher scores (84.37±10.86) than those aged 60 and above (72.85±8.59, p=0.016, indicating statistical significance). Korner et al, Athwal et al identified age as a significant determinant of functional recovery.[22,29] This has been attributed to the superior bone quality, enhanced rehabilitation adherence and less age-related comorbidities observed in younger individuals.

The lateral projection of postoperative radiographs revealed adequate alignment, restoration of joint congruity and secure fixation achieved with orthogonal dual plating (Figure 3). Range-of-motion workouts commenced promptly after verifying construct stability. MEPS was categorized based on fracture subtype, showing that C1 fractures yielded the most favorable outcomes, succeeded by C2 fractures, whilst C3 fractures exhibited the lowest mean scores. The clinical trend aligns with the findings of Ali et al and Lee et al which indicate that increased fracture complexity correlates with increased functional limitation, especially in terminal extension.[18]

The p value did not reach statistical significance (p=0.068), although the clinical pattern aligns with these results. In this study, eighty-six percent of patients achieved good to outstanding outcomes, a proportion comparable to the 78–85 percent reported by Sanchez-Sotelo et al and Shin et al for dual-plate fixation operations.[28,30]

This prospective design with predefined outcomes enhances robustness and addresses the evidence gap in Indian contexts, in contrast to previous retrospective findings. These data indicate that robust anatomical repair with dual-plate fixation, along by early mobilization, may produce beneficial outcomes for all fracture types, including difficult C3 injuries. However, age and fracture complexity remain critical prognostic factors, as demonstrated by our research findings and the current body of literature.

CONCLUSION

The present prospective analysis shows that dual-plate osteosynthesis can safely and successfully treat AO type C distal humeral fractures, restoring function and radiological fusion. Younger patients have better recuperative routes due to bone integrity and rehabilitative potential. Although C1 fracture morphology patients had higher functional scores, inter-subtype differences were not statistically significant. The prospective approach and use of standardized functional indicators make this study strong, but the small cohort size and brief surveillance duration may limit results' external validity. Thus, multicentric studies with larger sample sizes and longer follow-ups are needed to determine this fixation strategy's durability, complication radio spectrum and prognostic factors.

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