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Assessment of the Surgical Outcomes of the Distal Humerus Intra-Articular Fractures

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Abstract

Fractures of the distal humerus account for 2-6% of all fractures and pose significant challenges due to articular involvement, comminution, and osteopenia. This study evaluates the functional and radiological outcomes of intra-articular distal humerus fractures (AO Type C) managed with open reduction and internal fixation using orthogonal locking compression plates through a posterior approach with chevron olecranon osteotomy. In this prospective study, 30 patients (20 males, 10 females) with Type C distal humeral fractures (C1 = 10, C2 = 16, C3 = 4) underwent surgical treatment and were followed for a mean duration of 6 months. Causes included motor vehicle accidents (21 cases), accidental falls (7 cases), and assault (2 cases). The mean time to radiological union was 12.7 weeks. Functional outcomes assessed via the Mayo Elbow Performance Score (MEPS), which showed excellent in 12 cases, good in 10, fair in 4, and poor in 4, yielding a 73.3% good to excellent outcome rate. Complications included ulnar nerve paraesthesia (4 cases), superficial infection (4 cases), heterotopic ossification (4 cases), elbow stiffness (2 cases), and hardware prominence (2 cases). Operative management of Type C distal humerus fractures with bicolumn orthogonal locking plates provides stable fixation, facilitates early mobilisation, and results in a high union rate with satisfactory functional outcomes and acceptable complication rates.

Keywords: *orthogonal plating, distal humerus, locking compression plate, olecranon osteotomy, modified tension band wiring*

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1. Introduction

Fractures of the distal humerus comprise approximately 2% of all fractures and nearly one-third of all humerus fractures, making them relatively uncommon in adults. The overall incidence of distal humeral fractures was 5.7 cases per 100,000 population per year, with an equal male-to-female ratio (Robinson et al., 2003). Fractures due to falls (low energy) are most common in the elderly, while those resulting from trauma (high-energy) are common in younger age groups (Vala et al., 2017).

The Management of distal humerus fractures has advanced significantly since the 1980s, as the worldwide availability of AO principles of plate and screw fixation (Melton et al., 1998). Recent advances include the widespread availability of CT scans with three-dimensional reconstruction, improved understanding of the benefits of parallel and orthogonal plating techniques (Carson et al., 2006), availability of pre-contoured peri-articular plates, and the selective use of total elbow arthroplasty (Davis et al., 2000; Sanchez-Sotelo, 2012).

Open reduction and internal fixation with early mobilisation has been shown to yield superior outcomes than non-surgical management for intra-articular distal humerus fractures (Zagorski et al., 1986). However, controversy remains regarding

optimal management strategies, particularly in elderly patients with osteopenia comminution and structural bone loss (Sanchez-Sotelo, 2012).

Composite challenges in distal humerus fracture management include articular involvement, metaphyseal comminution, bone loss and osteopenia. An attempt to achieve a painless, stable yet mobile elbow requires a systematic approach (Jupiter & Mehne, 1992; London, 1981). Restoration of painless and satisfactory elbow function after a fracture of the distal humerus requires anatomic reconstruction of the articular surface, restitution of the overall geometry of the distal humerus, and stable fixation of the fractured fragments to allow early and full rehabilitation (Jupiter et al., 1985; John et al., 1994; Letsch et al., 1989). The aim of this study was to evaluate functional as well as radiological outcomes of AO type C distal humerus fractures treated by the Olecranon osteotomy approach orthogonal plating.

Relevant Literatures

The distal humeral shaft is triangular-shaped in cross-section with its apex directed anteriorly. As the shaft approaches the distal humerus, it bifurcates into two divergent cortical columns, termed the medial and lateral columns. The medial column diverges approximately 45 degrees from the humeral shaft in the coronal plane and terminates as the medial epicondyle. The lateral column, in the coronal plane, diverges at approximately 20 degrees from the shaft. As the lateral column extends distally, it curves anteriorly, creating a 35- to 40-degree angle with the shaft in the sagittal plane. In the coronal plane, the trochlea is more distal than the capitellum, resulting in a valgus alignment of 4 to 8 degrees. Overall, when the ulna is included, the elbow exhibits a valgus angle of 10-17 degrees in extension, termed the carrying angle. Axially, the distal humerus articular surface is internally rotated 3 to 8 degrees; therefore, as the elbow flexes, it also internally rotates, resulting in slight varus alignment (Graftiaux, 2015).

The elbow is anatomically a trochoid-ginglymoid joint, meaning that it has trochoid (rotatory) motion through the radiocapitellar and proximal radioulnar joints and ginglymoid (hinge-like) motion through the ulnohumeral joint. An understanding of the complex bony anatomy of the elbow, the soft-tissue stabilisers, and the adjacent neurovascular structures is imperative for the surgical treatment of distal humerus fractures (Dunning et al., 2001).

The LCL complex consists of the radial collateral ligament, the lateral ulnar collateral ligament (LUCL), and the annular ligament. The LCL complex functions as an important restraint to varus and posterolateral rotatory instability (Dunning et al., 2001; Imatani et al., 1999). The MCL consists of an anterior bundle, a posterior bundle, and a transverse ligament. The MCL functions as an important restraint to valgus and posteromedial rotatory instability (Armstrong et al., 2002; O'Driscoll et al., 1992).

The trans-olecranon osteotomy approach, considered the gold standard for the management of distal humeral fractures, was first described by Cassebaum (1969) and achieved good results. Chen G (as cited in Huang et al., 2005) in 2011, came to the conclusion after analysis of 67 patients, that ORIF via the triceps-sparing approach, confers inferior functional outcomes for intercondylar distal humerus fractures in patients over the age of 60 years, for whom the olecranon osteotomy approach may be a better choice.

For early rehabilitation, the fractures should be fixed with a stable construct. The stable fixation is achieved by internally fixing the reconstructed articular block, with the shaft, by plating on both pillars. These plates can be placed either posteriorly on the lateral side and over the ridge, on the medial side (perpendicular or orthogonal plating) or over ridges on both sides (parallel plating) (Helfet & Hotchkiss, 1990).

In the last quarter of the century, improved surgical outcomes for distal humeral fractures were reported. The AO-ASIF group set out their principles of anatomical articular reduction and rigid internal fixation through their perpendicular plating techniques. Several subsequent clinical studies reported good–to–excellent results with 90–90 plating (Helfet & Hotchkiss, 1990).

Following the introduction of the parallel plating concept, numerous biomechanical studies compared parallel and perpendicular plating to validate the superiority of parallel plating. Zalavras et al. (as cited in Atalar et al., 2017) concluded that a higher degree of stiffness and a higher degree of resistance in torque, cyclical varus loading, axial and sagittal loading to failure were exhibited by parallel plating compared to orthogonal plate constructs. The perpendicular technique requires less soft-tissue dissection, is technically easy, and reports of nonunion in this technique are statistically insignificant.

In 2001, O'Driscoll et al. defined the principles of fixation of these fractures using the parallel plating technique. A study on "Biomechanical comparison of orthogonal versus parallel double plating systems in intraarticular distal humerus fractures" by Atalar et al. (2017) showed that both plating systems had similar biomechanical stabilities when anatomic plates with distal locking screws were used.

In a review of current treatment concepts for distal humerus fractures, Amir et al. (2016) concluded that open reduction and internal fixation remains the gold standard, and that parallel and perpendicular plating have shown similar clinical outcomes. Total elbow arthroplasty has proven to be an adequate treatment option for older patients, particularly those with low bone density.

A review of complications of open reduction and internal fixation of distal humerus fractures by Savvidou et al. (2018) concluded that the open reduction with dual parallel or orthogonal locking anatomical plates is considered the gold standard for the treatment of distal humerus fractures. However, high complication rates, even in young patients, after internal fixation remain a main concern, highlighting the need for meticulous technique and experience.

Mayo elbow performance score (MEPS) can be applied for functional evaluation of the elbow joint (Cusick et al., 2014). It evaluates pain, range of motion, stability, and functional tasks, with a maximum score of 100 points. Classification is as follows: Excellent >90; Good: 75-89; Fair: 60-74; Poor: <60.

2. Materials and methods

2.1 Study Design

A Prospective study was conducted to evaluate the functional outcome of distal humeral fractures treated with orthogonally applied locking compression plates.

2.2 Setting and Duration

The study was carried out in the Department of Orthopaedics and Trauma Surgery, College of Medical Sciences - Teaching Hospital, Bharatpur, Nepal, over a one year period from October 2019 to September 2020.

2.3 Study Group

The study group comprised 30 Patients with distal humeral fractures who underwent osteosynthesis using the orthogonal plating technique. Ethical clearance was obtained from the institutional ethics committee, and written Informed consent was obtained from all participants.

Inclusion Criteria

• Skeletally mature individuals aged 18 years or older.
• Diagnosis of a closed, intra-articular fracture of the distal humerus classified as AO/OTA Type C (C1, C2, or C3) confirmed radiographically (via plain radiographs and computed tomography scan).
• Presentation within three weeks of the initial injury.
• Indication for operative management with open reduction and internal fixation (ORIF) using a dual-plating construct.

Exclusion Criteria

• Open fractures (Gustilo-Anderson Type I, II, or III).
• Pathological fractures or fractures associated with significant bone loss require augmentation.
• Previous significant injury or surgery to the affected elbow that could compromise functional assessment.
• Associated neurovascular injury requiring immediate surgical intervention beyond fracture fixation.

2.4 Sampling Technique

A non-probability purposive study: all patients with closed distal humerus intra-articular fractures presenting to the emergency department or outpatient department who met the inclusion criteria were included in the study.

2.5 Sample Size

Sample size was calculated by using the Cochran equation as:

$n_0 = Z^2pq / e^2$

Where,

n_0 is the sample size

Z^2 is the abscissa of the normal curve that cuts off an area at the tails, Z= 1.96 for 95% level of confidence

p is the estimated proportion of an attribute that is present in the population

q is 1-p. For this study value of p 2% (i.e., 0.02)

Now, calculating the sample size

$n_0= (1.96)^2(0.02) (1-0.02)/ (0.05)^2= 30.12.$

2.6 Data Analysis Plan

Data were entered using EpiData software and analysed using SPSS version 20. Frequency distributions and cross-tabulations between the dependent and independent variables were presented, and the basic background and characteristics of the respondents were summarised.

2.7 Ethical Considerations

Ethical approval was obtained from the institutional ethics Committee. Written informed consent was obtained from all participants after explaining the study in a language they understood.

2.8 Treatment Protocol

Clinical History and Examination

A detailed primary history, including name, age, sex, date of injury, mechanism of injury, residential address, occupational status, and associated injuries, was recorded on admission. The patient's general condition and vitals were noted. X-rays were obtained in both true anteroposterior and true lateral views with slight traction after removing any previously applied slab.

3D reconstruction CT views of the elbow joint were taken for evaluating the number of fragments, degree of comminution and displacement, if required, which aided in planning of surgery, type of implant and placement of screws.

Laboratory Work Up

The patients underwent basic investigations required for a pre-anaesthetic checkup. Associated medical comorbidities were dealt with if present.

Surgical Technique

The patients were given general or regional anaesthesia and positioned in the lateral position, with the involved limb supported on bolsters on the OT table.

Through a midline posterior skin incision, the subcutaneous and deep fascia are incised, and before proceeding further, the ulnar nerve is identified, dissected out and retracted gently with an umbilical cotton tape or a rubber tape. Then the Chevron V-shaped olecranon osteotomy was done incompletely with a saw and completed with an osteotome to visualise the articular surface, as the olecranon osteotomy helps in wide exposure of intra-articular fragments in type C fractures.

3. Results

A total of 30 patients with intra-articular distal humerus fractures (AO Type C) were included in this prospective study. The cohort consisted of 20 males (66.7%) and 10 females (33.3%), with a mean age of 43 years (SD ± 18.4) and a range of 20 to 85 years. The demographic and injury characteristics of the patients are summarised in Table 1.

Table 1: Patient Demographics and Injury Characteristics (n=30).

Characteristic	Value
Mean Age (years)	43 (SD ± 18.4)
Sex, n (%)	
Male	20 (66.7%)
Female	10 (33.3%)
Mode of Injury, n (%)	
Motor Vehicle Accident (MVA)	21 (70.0%)
Accidental Fall	7 (23.3%)
Assault	2 (6.7%)
Fracture Type (AO), n (%)	
C1	10 (33.3%)
C2	16 (53.3%)
C3	4 (13.3%)
Side of Injury, n (%)	
Right	16 (53.3%)
Left	14 (46.7%)

(Source: WHO e-SPAR)

The predominant mode of injury was motor vehicle accidents (70%), particularly among male patients. Fourteen patients (46.7%) had associated skeletal injuries, the most common being fracture of the pubic rami (n=5) and distal radius (n=4). Two patients presented with preoperative median nerve palsy.

All patients were operated on via a posterior approach with chevron olecranon osteotomy. The average time from injury to surgery was 6 days (range: 5-17 days), and the mean surgical time was 110 minutes (range: 60-180 minutes).

3.1. Functional and Radiological Outcomes

Patients were followed up for a mean duration of 6 months. Functional outcome, assessed using the Mayo Elbow Performance Score (MEPS), is presented in Figure 1. Excellent and good results were found in 12 (40%) and 10 (33.3%) patients, respectively, yielding an overall success rate (good-to-excellent outcomes) of 73.3%. Four patients (13.3%) had a fair outcome, and 4 (13.3%) had a poor result.

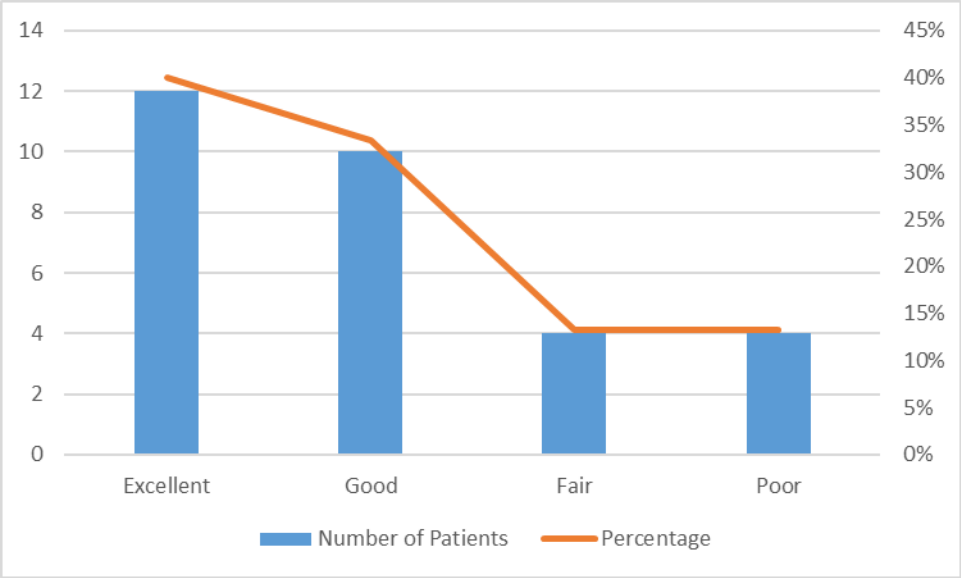

Figure 1: Functional Outcome based on Mayo Elbow Performance Score (MEPS)

The success rate was higher in patients younger than 43 years (80%) compared to those 43 years and older (70%). Similarly, the success rate was 75% for males and 70% for females. When analysed by fracture type, success rates were 80% for C1, 75% for C2, and 50% for C3 fractures.

Radiological union was achieved in all patients. The average time to union was 12.7 weeks.

3.2. Complications

The complications encountered during the study period are detailed in Table 2. The most common complications were ulnar nerve paresthesia (n=4, 13.3%), superficial infection (n=4, 13.3%), and heterotopic ossification (n=4, 13.3%). Two cases of stiffness and two cases of hardware prominence were also noted. All infections resolved with conservative antibiotic treatment or debridement. There were no instances of nonunion, implant failure, or mortality.

Table 1: Postoperative Complications (n=30)

Complication	Number of Patients (n)	Percentage (%)
Ulnar Nerve Paresthesia	4	13.3%
Infection	4	13.3%
Heterotopic Ossification	4	13.3%
Stiffness	2	6.7%
Hardware Prominence	2	6.7%

4. Discussion

The treatment of distal humerus fractures with intra-articular extension by bi-column locking compression plates applied orthogonally is studied in detail. The treatment is challenging due to the complex three-dimensional geometry. Poor functional outcomes like stiffness, non-union and implant failure make these fractures challenging to treat. In our study, we focused on the functional outcome of these patients, strictly adhering to principles of good anatomical alignment, absolute stabilisation, and early mobilisation.

The mean age of patients in our study is 43 years, comparable to that reported by Shin et al. (2010; 42 years). The younger age group had a higher success rate (88%) than the elderly group. This may be attributed to poor bone quality and patient nonadherence, resulting in functional outcomes such as stiffness.

Among the approaches used in this study, Chevron olecranon osteotomy was most widely used, achieving a very good success rate (88.9%). A study by Elmadag et al. (2014) showed that olecranon osteotomy yielded better outcomes than the paratricipital approach in a cohort of 54 patients.

Anterior transposition of the ulnar nerve was performed in all 30 patients in our study; 4 patients had ulnar neuropraxia, which recovered completely within 6 months. In a study by Ring et al. (2000), the complications reported following olecranon osteotomy included bursitis, hardware prominence, and a broken or migrated K-wire. In this study, one case of hardware prominence was encountered.

In the study by Qi-X et al. (2010), 21 cases of distal humerus fractures were operated on using the paratricipital approach; one case of myositis ossificans was reported. In our study, 2 of the 4 cases developed stiffness due to heterotopic ossification.

In the study by Babhulkar et al. (2011), 80 intra-articular fractures were treated with orthogonal plating, and 86% of cases achieved an excellent outcome. Kaiser et al.'s (2011) study showed 22 patients treated with orthogonally applied LCP plates. The mean MEPS scelmadaore was 84.7. The complications reported were ulnar sensory neuropathy, which recovered incompletely in 1 case. All patients had achieved stable reduction and union during follow-up. Our study found a mean MEPS of 80.33, with all patients achieving union. The mean MEPS of 80.33 in this aligns with satisfactory outcomes but is slightly lower than the 84.7 reported by Kaiser et al. (2011). This discrepancy may be attributed to the inclusion of more complex C3 type fractures (13.3%) and a slightly older mean patient age, factors associated with greater surgical challenge and potentially slower functional recovery. Conversely, the mean surgical time of 110 minutes was notably shorter than the 123 minutes reported by Holub et al. (2012) for conventional plates. This efficiency gain is likely attributable to the use of pre-contoured locking compression plates, which reduce intraoperative time spent on plate contouring and provisional stabilisation.

In the study by Holub et al. (2012), the outcomes of conventional reconstruction plates and LCPs were compared; LCPs yielded excellent results, particularly in intra-articular distal humerus fractures. The average operating time was 123 minutes using conventional plates. Our study had an average time of 110 minutes, which may be attributed to the anatomically precontoured plates, which do not require any contouring to fit to the bone.

Lee et al. (2014) compared the outcomes of parallel and orthogonal plating techniques using the distal humerus LCP and found no significant difference between the techniques. Stoffel et al. (2008) reported the same result in their study comparing parallel and perpendicular locking plate systems for comminuted distal humerus fractures. No intergroup differences were noted in operating time, time to union, or functional recovery. Athwal et al. (2009) reported outcomes in 37 patients treated with a distal humerus LCP using the parallel plate technique; 5 of 24 patients (16%) experienced postoperative nerve injuries. In this study, no postoperative nerve injuries were seen. This may be attributed to the safer, easier dissection required by the orthogonal plating technique compared with the parallel plating technique.

This study has several limitations that should be acknowledged. The relatively small sample size of 30 patients and the short mean follow-up duration of six months may not capture the full spectrum of long-term complications, functional decline, or the eventual need for hardware removal. The single-centre design and non-probability sampling method limit the generalizability of the findings to broader populations. Furthermore, the absence of a direct comparative control group (e.g., patients treated with parallel plating or nonoperative management) precludes definitive conclusions regarding the superiority of the orthogonal plating technique used here. Finally, the functional assessment relied on a single clinician-reported score (MEPS), which may not fully reflect patient-reported outcomes or satisfaction.

5. Conclusion

Operative treatment of patients with distal humerus intra-articular fractures has been successful. It has a favourable functional and radiological outcome. Complications are minimal, and outcomes are satisfactory in patients with type C distal humerus fractures who underwent bicolumn locking compression plate fixation applied orthogonally by the olecranon osteotomy approach. It facilitates early postoperative elbow mobilisation and results in a high union rate. Hence, it is concluded that operative management is a good primary treatment for the distal humerus intra-articular fractures.

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