



## RESEARCH ARTICLE

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## Functional Outcome of AO Type C Distal Humerus Fracture Managed with Orthogonal Plating: Retrospective Study

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### ABSTRACT

**Introduction:** Distal humeral fractures have an estimated incidence in adults of 5.7 per 100,000 persons per year. The concept of orthogonal locking plating, which involves placing one plate along the medial column of the distal humerus and the other plate along the lateral column, with the screws in the distal fragment interdigitating with each other, restoring the 'tie-beam arch' of the distal humerus.

**Materials and Methods:** This retrospective trial involves 37 patients with distal humerus AO type C operated between May 2018 and Feb 2020 at a tertiary care center in Navi-Mumbai, India with orthogonal plating with 13 patients operated with paratricipital approach and 24 patients operated with olecranon osteotomy. The results were analyzed with the DASH scoring system and MEPS.

**Results:** of 37 patients operated 15 were male and 22 were female, depending on the surgeon's preference, 4 cases of type C1 and 9 cases of type C2 were operated on with triceps sparing approach and all Type C3 fractures were operated with olecranon osteotomy approach. All the cases showed bone union at 8.4 weeks  $\pm$  2.3 weeks, no case showed non-union or malunion, 2 cases showed superficial infection but did not require any surgical intervention and were managed with oral antibiotics, and one case developed a deep infection which later on developed chronic osteomyelitis and fixed flexion deformity, was managed with hardware removal at 15 months after repeated wound wash and debridement.

**Conclusion:** The present study observed orthogonal dual plating for AO Type C distal humerus fractures to be an effective surgical option as it helps in achieving good anatomical reconstruction, stable fixation, and early mobilization.

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### Introduction

For many years, Distal Humerus intra-articular fractures were regarded to be treated nonsurgically with the "bag-of-bones" technique. However, over the past 2 decades, the literature has documented a consensus on two issues. First, these fractures should indeed be reduced and treated with internal fixation. Second, the quality of the outcome is related to the stability of the internal fixation, with poor outcomes expected in those circumstances in which stability is not achieved [1]. Fractures of the distal humerus have been considered very challenging because of the complicated anatomy, a small fracture fragment and the limited amount of subchondral bone, and osteoporosis of the distal humerus [2].

Distal humeral fractures have an estimated incidence in adults of 5.7 per 100,000 persons per year. These injuries occur in a bimodal distribution, with an early peak in young males, twelve to nineteen years of age, as a result of high-energy trauma like motor vehicle accidents and the second peak in elderly women, with osteoporotic bone, as a result of falls [3].

The articular surface of the distal humerus should be reconstructed anatomically unless bone is missing. If the bone is missing, 2 important principles should be taken into consideration. First, the anterior aspect of the distal humerus is the critical part of the articulation that needs to be fixed to have a functional joint;

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reconstruction of the posterior half is important but not as critical. Second, stability of the articulation requires the medial trochlea and either the lateral half of the trochlea or the capitellum. Thus, the medial trochlea is essential to obtain a stable and well-aligned joint. Complex fractures of the distal humerus are not amenable to single-column plating systems, which are proven to be less stable to loads compared to double-column plating methods [4]. Double-column plating is currently the treatment of choice for the intra-articular fractures of distal humerus based on the various clinical and biomechanical studies [5]. The concept of orthogonal locking plating, which involves placing one plate along the medial column of the distal humerus and the other plate along the lateral column, with the screws in the distal fragment interdigitating with each other, restoring the 'tie-beam arch' of the distal humerus [6].

Numerous approaches for these types of fractures have been mentioned in the literature, including olecranon osteotomy, triceps lifting (Campbell's approach), triceps splitting, and sparing [7].

This study aims to evaluate the functional outcome of distal humerus intra-articular fractures managed with orthogonal plating.

### Materials and Methods

This retrospective trial involves the patients operated on between May 2018 and Feb 2020 at a tertiary care center in Navi-Mumbai, India. The inclusion criteria include patients more than 18 years of age, and the presence of an AO type 1 C distal humerus intercondylar fracture [8]. Patients with pre-existing deformity, disability, infection, pathological fractures, extra-articular fractures, previous surgical intervention in the involved elbow, unfit for surgery, or failure to give consent were excluded from the study [9]. A total of 37 patients were found to be eligible for the study. There were 15 male and 22 female patients. 13 patients were managed with the Paratricipital approach and 24 with Olecranon Osteotomy depending upon surgeon's preference and expertise. The mean age was 48.3 years (range, 26–78 years), and the dominant side was involved in 19 cases. The mean time from the date of injury to operation was 4.3 days (range, 2–7 days). The outcome was calculated at 3 and 6 months using the disability of arm, shoulder, and hand (DASH) scoring system and the Mayo Elbow Performance Score (MEPS)

### Surgical Technique

A midline posterior incision was used with a slight lateral curve on the olecranon [10]. The ulnar nerve was identified first, and the release of the ligament of Struthers and medial intermuscular septum was done to transpose the ulnar nerve if required. All fractures were fixed as per AO principles using bicolumnar plating.

In the Olecranon Osteotomy approach, an interval was created between the medial intermuscular septum and the triceps. Also, the triceps was lifted from the posterior aspect of the humerus to create a lateral window. Chevron shape osteotomy of the ulna was done with apex distally at approximately 2 cm from the olecranon tip. Dissection extended proximally as required and the olecranon fragment was wrapped with a saline-soaked gauze piece sutured proximally. This completed the exposure of fracture.

The osteotomy site was fixed with two 1.8-mm (0.072") smooth K wires that perforate the anterior cortex distal to the coronoid process and were stabilized with an 18-gauge wire by tension band wire principles. In Triceps sparing approach, a posterior midline incision was used and a full-thickness fasciocutaneous flap was created. The ulnar nerve was identified and dissected to take it out of harm's way. Anterior transposition of the ulnar nerve was performed in three patients. The medial and lateral borders of the triceps muscle were identified and separated from the respective intermuscular septum to form the medial and lateral windows. By blunt dissection, both windows were connected and the triceps muscle was separated from the posterior part of the distal humerus. The fat pad from the olecranon fossa was excised. These two windows provided adequate visualization of the articular surface of the distal humerus from the medial and lateral sides [3].

### Fixation

The intra-articular fragments were first reduced and provisionally fixed with K wires followed by fixation with partially threaded cannulated screws to convert the complicated inter-condylar fractures to supracondylar varieties [5]. The reduced articular fragment was then fixed to the shaft of the humerus. If articular bones were severely comminuted, either condyle was first reduced and fixed to the shaft as it provided a good key for reduction. Now articular fragments were reconstructed and the opposite condyle was also fixed to the main bone. Our goal was to place at least 3 screws proximal and 3 screws distal to the fracture site in each column. The range of motion was checked intraoperatively, closure was done in layers. Active assisted range of motion was started was day 2 twice daily and serial radiographs were done on the 2<sup>nd</sup>, 6<sup>th</sup>, and 12<sup>th</sup> weeks

### Results

The mean age of the patients was 48.3. 15(40.54) cases were males, and 22(59.45) cases were females. Right-sided involvement was more frequent in the present study comprising 19(51.35) cases. 23(62.16) cases sustained a fracture due to a road traffic accident; 11(29.72) cases had a domestic fall and 3(8.10) cases had an assault resulting in a fracture. All the fractures were classified using the AO classification system. 6 cases were of type C1, 17 cases were type C2, and 14 cases were type C3. Depending on the surgeon's preference, 4 cases of type C1 and 9 cases of type C2 were operated with triceps sparing approach and all Type C3 fractures were operated with an olecranon osteotomy approach. The duration of surgery ranged from 150-180 minutes with a mean period of 160 minutes  $\pm$ 7 minutes. All the cases were followed up for 6 months, and 2 cases were lost to follow-up after 4 months. All the cases showed bone union at 8.4 weeks  $\pm$  2.3 weeks. No case showed non-union or malunion. 2 cases showed superficial infection but not did require any surgical intervention and were managed with oral antibiotics. One case developed a deep infection which later on developed chronic osteomyelitis and fixed flexion deformity, patient was taken for hardware removal at 15 months after repeated wound wash and debridement. One patient complained of implant impingement and was operated on with the removal of the implant at 18 months. The functional outcome was assessed with the DASH scoring system and MEPS.

All the patients showed no angular or rotational deformity with 19(51.35%) patients showing full extension, 10 (27.02%) patients showing extension lag between 0° to 5° and 8 (21.62%) patients showing extension lag between 5° and 15° except for one patient which showed fixed flexion deformity of 90° with no extension possible. The patient's satisfaction was excellent in 29 cases, good in 5 cases, fair in 2 cases, and poor in 1 case.

## Discussion

The primary goal in the management of distal humerus fractures is to achieve a stable elbow with a satisfactory painless range of motion. Distal humerus fractures have proved to be problematic both to the surgeons and the patients. It is difficult to re-establish anatomical reduction to allow early mobilization and rehabilitation. The controversy between bicolumnar parallel plating and orthogonal plating continues to be a matter of debate. In studies conducted in the past three decades, similar results have been observed in both fixation techniques in terms of functional range of motion, complications, and MEPS. The orthogonal plating method was observed to be preferred in cases of coronal shear fractures (where the posterior to anterior fixation can provide additional stability to the intraarticular fractures), while the parallel plating method was observed to be the preferred technique used for fractures that occur at the most distal end of the humerus (as more stability can be obtained by providing additional screws in the distal fragments), the placement of the lateral plate may be difficult because of the muscles and ligaments that adhere to the lateral column and pose a risk to the radial nerve [11]. Posterolateral plate placement is much easier. Got et al in a study concluded that 90-90 plating had greater resistance to torsional loading compared with parallel plating in cadaver models [12].

Various approaches have developed since the advent of operative management of distal humerus intraarticular fractures. Depending on the surgeons' preference, in the present study 4 Type C1 and 9 Type C2 cases were operated on with the triceps sparing approach and all Type C3 fractures were operated on with the Olecranon osteotomy approach. All the cases showed bone union irrespective of approach. Both approaches have distinct advantages and disadvantages. For patients who undergo olecranon osteotomy, better visualization of intra-articular surface, anatomical reduction, and fixation of osteochondral fragments are easier. In a comparison anatomic study done on cadavers it was found that only 35% articular surface is adequately exposed in triceps splitting approach, 46% articular surface is exposed in triceps reflecting and 57% of the articular surface is exposed with transolecranon approach [13-15].

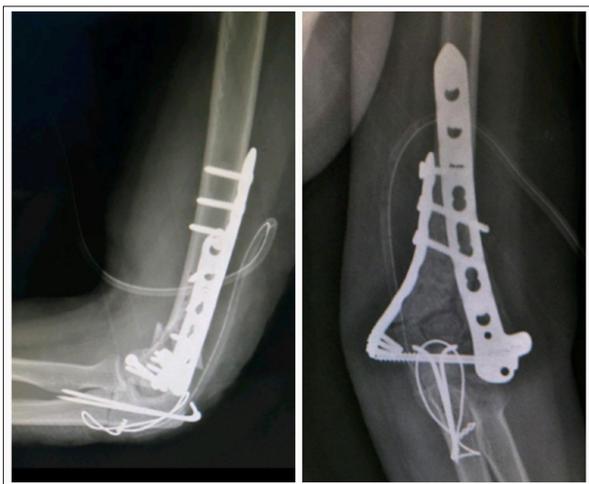
Many surgeons avoid transolecranon approach to avoid the associated complications. Henley et al reported a 57% incidence of complications with the transverse osteotomy, including symptomatic prominence of the hardware (K wire), broken tension band wire, delayed union, and non-union [16]. A retrospective study comparing the two approaches, by McKee et al., showed equivalent outcomes concerning the Disabilities of the Arm, Shoulder, and Hand (DASH) and Short Form-36 (SF-36) scores

as well as objective muscle strength testing (n = 25 patients) [31]. However, the authors concluded that three of eleven patients had reoperation for removal of the olecranon implant in the osteotomy group [17].

Literature alludes to the need for anterior transposition of the ulnar nerve to prevent ulnar nerve damage, however, a study conducted by Wang KC et al, observed anterior transposition of the ulnar nerve is associated with a significant 5-fold increase in ulnar nerve neuropathy [18,19]. retrospectively reviewed the results in two groups of patients with no preoperative ulnar nerve symptoms who were treated with transposition or no transposition. They reported an overall 20% rate of documented ulnar nerve dysfunction (fourteen of sixty-nine patients) postoperatively, with no significant differences between the two groups. The authors concluded that the anterior transposition of the nerve was not protective in their analysis. In the present study, out of 37 patients 29(78.37) patients showed excellent or good results with a mean MEPS score of 83.28±9.31 (range 58 - 100), DASH scores of 19.81±11.39, total Range of motion 103.51°±10.41 with extension lag 17.69°±6.41. The group with C1 and C2 fracture patterns showed better functional outcomes. No statistically significant difference in the outcomes among the groups operated with olecranon osteotomy and triceps sparing groups was observed. The study observed 4 cases of ulnar nerve palsy out of which in three cases anterior transposition of the ulnar nerve was performed and the ulnar nerve palsies recovered within 3 months, two cases of superficial infection which were treated with antibiotic cover, and one case which eventually developed into chronic osteomyelitis associated with heterotopic ossification along the medial column was observed. A study conducted by Aslam and Willet reported good to excellent results in 70% of patients with a mean flexion arc of 112° and grip strength of 82% compared to normal side in 26 patients of type C distal humerus fractures treated with dual orthogonal plating [20]. The current study reported a good union rate, lesser complications, and good functional margins.



**Figure 1:** Radiograph of AO type C3 Distal Humerus Fracture



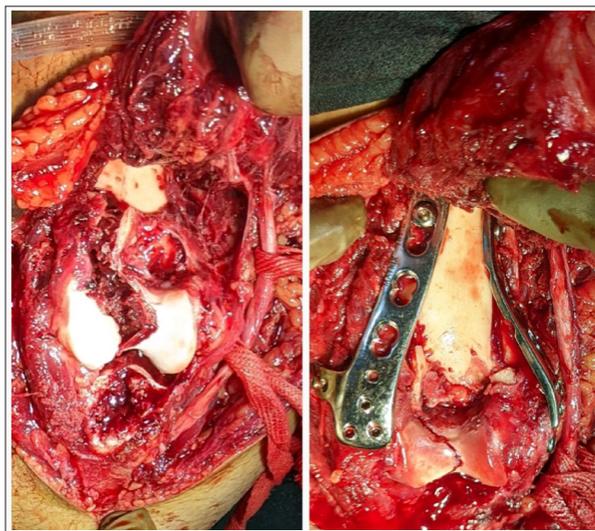
**Figure 2:** Radiograph of AO Type C3 Distal Humerus Fracture Operated with Orthogonal Plating with Osteotomy



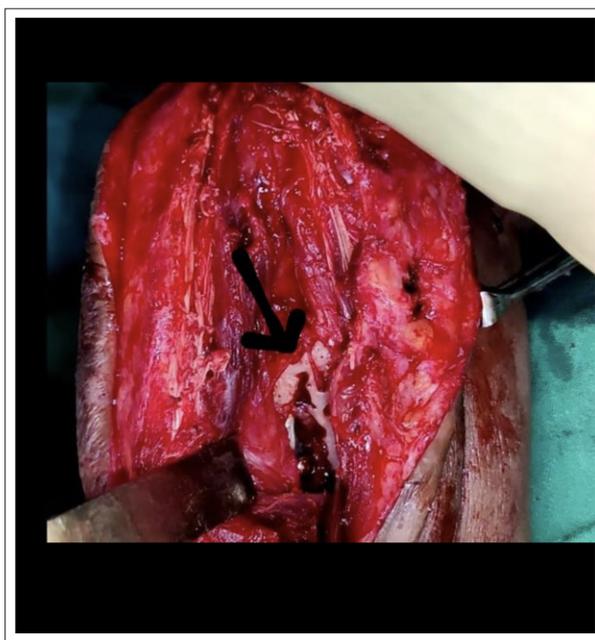
**Figure 3:** Radiograph of AO Type C2 Distal Humerus Fracture



**Figure 4:** Radiograph of AO Type C2 Distal Humerus Fracture Operated with Orthogonal Plating without Osteotomy



**Figure 5:** Intraoperative Pictures of Pre and Post-Fixation with Orthogonal Plating



**Figure 6:** Arrow Depicting Heterotopic Ossification over the Medial Column Plate

### Conclusion

The present study observed orthogonal dual plating for AO Type C distal humerus fractures to be an effective surgical option as it helps in achieving good anatomical reconstruction, stable fixation, and early mobilization. It addresses the difficulties encountered while managing these fractures and provides a stable fixation with predictable and satisfactory results and an early return to function.

### Disclosures

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**Declaration of Conflicting Interests:** All the Authors declares that there is no conflict of interest.

**Research Ethics and Patient Consent:** Written consent for publication of patient details were obtained from the parent/guardian.

## References

- [1] WO Driscoll, Rochester MN. Optimizing stability in distal humeral fracture fixation Shawn, *Journal of Shoulder and Elbow Surgery*. 2005; 186-194.
- [2] Bi O Jeong, Dong Ki Lee. Treatment for type C fractures of the distal humerus with the LCP distal humerus system, *European Journal of Orthopaedic Surgery & Traumatology*. 2012; 22: 565-569.
- [3] Vishal Yadav, Pulak Sharma, Ashish Gohiya. Functional outcome of intraarticular distal humerus fracture fixation using triceps-sparing paratricipital approach, *Indian Journal of Orthopaedics*. 2016; 50: 595-601.
- [4] Rajeev Kelkar, Deepak Singh Rajput. Functional outcome of orthogonal plating in treatment of distal humerus fracture, *International Journal of Orthopaedics Sciences*. 2018; 4: 278-283.
- [5] KC Kapil Mani, Parimal Acharya, RC Dirhga Raj, Arun Sigdel. Functional outcomes of type C distal humerus fractures in adults fixed by orthogonal double plating. 2018; 15: 15-20.
- [6] Deepak Vasishtha, Sandeep Naik, Santosh Nandi, Shreepad Kulkarni. Clinical outcome of treatment of intra-articular distal humerus fracture with open reduction and internal fixation by orthogonal locking plate: a prospective study, *International Journal of Research in Orthopaedics*. 2020; 6: 471-476.
- [7] Mehmet Elmadag, Mehmet Erdil, Kerem Bilsel, Mehmet Ali Acar, Nejat Tuncer, et al. The olecranon osteotomy provides better outcome than the triceps-lifting approach for the treatment of distal humerus fractures, *European Journal of Orthopaedic Surgery & Traumatology*. 2014; 24: 43-50.
- [8] Wade T Gofton, Joy C MacDermid, Stuart D Patterson, Ken J Faber, Graham JW King, et al. Canada Functional Outcome of AO Type C Distal Humeral Fractures, *J Hand Surg*. 2003; 28: 294-308.
- [9] Sanjiv Kumar, Sudhir Singh, Dharmender Kumar, Neeraj Kumar, ReetuVerma. Intercondylar Humerus Fracture Parallel Plating and Its Results, *Journal of Clinical and Diagnostic Research*. 2015; 9: 1- 4.
- [10] Rahul Singh, Naman Kanodia, Harveer Singh. Outcome following olecranon osteotomy versus paratricipital approach for complex intra-articular (AO 13-C) fracture of distal humerus: a prospective comparative study, *J Shoulder Elbow Surg*. 2019; 28: 742-750.
- [11] Sang Ki Lee, Kap Jung Kim, Kyung Hoon Park, Won Sik Choy. A comparison between orthogonal and parallel plating methods for distal humerus fractures: a prospective randomized trial, *Eur J Orthop Surg Traumatol*. 2014; 24: 1123-1131.
- [12] Got C, Shuck J, Biercevicz A, Dave Paller, Mary Mulcahey et al. Biomechanical comparison of parallel versus 90-90 plating of bicolmn distal humerus fractures with intra-articular comminution, *J Hand Surg Am*. 2012; 37: 2512-2518.
- [13] Wilkinson JM, Stanley D. Posterior surgical approaches to the elbow: a comparative anatomic study, *J Shoulder Elbow Surg*. 2001; 10: 380-382.
- [14] Bryan RS, Morrey BF. Extensive posterior exposure of the elbow: a triceps-sparing approach, *Clin Orthop*. 1982; 166: 188-192.
- [15] Hoppenfeld S, deBoer P. *Surgical Exposures in Orthopaedics*. Philadelphia, PA: JB Lippincott, 1984; <https://www.abebooks.com/book-search/title/surgical-exposures-orthopaedics-anatomic-approach/author/hoppenfeld/>.
- [16] Henley MB. Intra-articular distal humeral fractures in adults, *Orthop Clin North Am*. 1987; 18: 11-23.
- [17] McKee MD, Wilson TL, Winston L, Schemitsch EH, Richards RR. Functional outcome following surgical treatment of intra-articular distal humeral fractures through a posterior approach, *J Bone Joint Surg Am*. 2000; 82: 1701-1707.
- [18] Ahmed AF, Parambathkandi AM, Kong WJG, Motasem Salameh, Aiman Mudawi et al. The role of ulnar nerve subcutaneous anterior transposition during open reduction and internal fixation of distal humerus fractures: a retrospective cohort study, *International Orthopaedics (SICOT)*. 2020; 44: 2701-2708.
- [19] Vazquez O, Rutgers M, Ring DC, Walsh M, Egol KA. Fate of the ulnar nerve after operative fixation of distal humerus fractures, *J Orthop Trauma*. 2010; 24:395-9.
- [20] Wang KC, Shih HN, Hsu KY, Shih CH. Intercondylar fractures of the distal humerus: routine anterior subcutaneous transposition of the ulnar nerve in a posterior operative approach, *J Trauma*. 1994; 36: 770-3.
- [21] Nadim ASLAM, Keith WILLETT. Functional outcome following internal fixation of intraarticular fractures of the distal humerus (AO type C), *Acta Orthop Belg*. 2004; 70: 118-22.