

## Management of Fractures of Distal End of Humerus by Triceps-Sparing Approach

Dr.M.Kishore Kumar<sup>1</sup>, Dr.Kalam<sup>2</sup>

<sup>1</sup>(Associate professor of orthopaedics, RIMS, Ongole)

<sup>2</sup>(Tutor, department of orthopaedics, RIMS, Ongole)

Corresponding Author: Dr.M.Kishore Kumar

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### Abstract

**Background:** Displaced intraarticular distal humerus fracture has been conventionally treated operatively with various triceps disrupting approaches. These approaches are associated with several complications, such as triceps weakness, nonunion or delayed union of osteotomy, implant prominence, and delayed mobilization of the elbow. We present the functional outcome of intraarticular distal humerus fracture fixation using a triceps-sparing approach which allows early elbow mobilization and preserving triceps strength.

**Materials and Methods:** Twenty patients with intraarticular distal humerus fracture were operated using triceps-sparing approach with orthogonal plate construct. There were 14 male and 6 female patients and average age was 35.05 years (range 18- 62 years). The mechanism of injury was fall from height (n = 3), road traffic accident (n = 12) and ground level fall (n = 5). Clinical, radiological, and functional assessment with Mayo Elbow Performance Index (MEPI) were obtained at follow up period.

**Results:** All fractures united primarily. At the mean follow up of 8.7 months (range 6-16 months), mean elbow flexion was 134.55° (range 121°–142°) and mean motion arc was 129.1°(range 106°-140°). The mean MEPI score was 95.75 points (range 80–100) with 18 excellent, and 2 good results. The mean flexion deformity or extension loss was 5.45° (range 5°–15°).

**Conclusion:** Open reduction and internal fixation of intraarticular distal humerus fractures with triceps-sparing approach provide adequate exposure with no adverse effect on triceps muscle strength and allows early initiation of elbow motion. We analyzed, age and injury to surgical interval with relation to functional range of elbow using Z-test which is insignificant.

**Key words:** Distal humerus, orthogonal plate, triceps-sparing surgical approach

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**MeSH terms:** Fracture fixation, internal, humerus, bone plates, elbow joint.

### I. Introduction

An intraarticular distal humerus fracture (AO type 13C) is a challenging condition for orthopedic surgeons. These fractures demand technically difficult operative treatment, often with a relatively high morbidity.<sup>1</sup> It is troublesome to choose an approach for intraarticular distal humerus that provides easy access for reduction and fixation of fracture with minimal soft tissue and extensor mechanism disruption.

Conventionally, intraarticular distal humerus fractures have been managed operatively using various surgical techniques, including olecranon osteotomy, triceps reflecting and splitting approaches. These approaches are often associated with complications, such as delayed union or nonunion at the osteotomy site, prominence of the implant, triceps weakness, wound dehiscence, triceps avulsion, delayed mobilization, and failure to gain early elbow function<sup>2-7</sup>

In 1972, Alonso-Llames described a “two-window” approach to treat supracondylar fractures in children where closed reduction had failed.<sup>8</sup> In 2003, this approach was expanded by Schildhauer *et al.*<sup>9</sup> for the treatment of distal humeral fractures with intraarticular extension. They described an extensor mechanism-sparing, paratricipital approach with bicolumnar visualization through medial and lateral windows, with the triceps insertion intact on the olecranon. There is limited literature focusing on the paratricipital approach to treat distal humerus fractures.<sup>9-13</sup>

We conducted a prospective, observational study on patients with intraarticular distal humerus fractures treated with the triceps-sparing approach, with the key aim of assessing the clinical and functional outcome in the Indian population.

## **II. Materials and Methods**

Twenty patients with distal humerus intraarticular fractures AO type 13C were included in this prospective and observational study and internal fixation was done using triceps-sparing approach between April 2017 and April 2019. Mean age at the time of surgery was 35.5 years (range 18-62 years). Of the 20 patients, 14 (70%) were male and 6 (30%) were female. The modes of injury were due to fall from height ( $n = 3$ ), road traffic accidents ( $n = 12$ ) and ground level fall ( $n = 5$ ). The fractures were classified according to AO/ASIF classification<sup>14</sup> on plain x-rays, 7 were of C1 type, 9 of C2 type, and 4 of C3 type. The mean interval from injury to surgery was 2.95 days (range 1-6 days). Patients who had a pathological fracture, multiple fractures in the same extremity, and preexisting joint pathology were excluded. Prior approval for the study was obtained from the Research Ethics Committee of our institute.

A written and informed consent was obtained from all the patients who were included in the study. Osteosynthesis was performed through posterior triceps-sparing approach using orthogonal plate constructs. All surgeries were performed by one senior author (AG) during the study period.

## **III. Operative procedure**

Some patients were placed under general anesthesia, and tourniquet, while the rest of the patients were placed under brachial block and tourniquet, all patients were placed in a lateral decubitus position with the affected arm and elbow resting over a support, and the forearm hanging freely to enable further flexion of the elbow.

A posterior midline incision was used and a full-thickness fasciocutaneous flap was created. The ulnar nerve was identified and dissected to take out of harm's way. Anterior transposition of the ulnar nerve was not required in any of the patients. The medial and lateral borders of triceps muscle were identified and separated from the respective intermuscular septum to form the medial and lateral windows. By blunt dissection, both windows were reconnected and the triceps muscle was separated from the posterior part of the distal humerus. The fat pad from olecranon fossa was excised. These two windows provided adequate visualization of the articular surface of the distal humerus from the medial and lateral sides.

First, the distal humerus articular fragments were reduced posteriorly anatomically under direct visualization or, if required, indirectly under fluoroscopy guidance. Although we cannot visualize anterior articular surface with this approach, however if distal and posterior articular surface was reduced anatomically anterior articular surface is automatically reduced. The intact sigmoid notch was used as a guide for reduction – if articular fragments are anatomically reduced, they will be evenly seated in the sigmoid notch. A drain tube was put under the triceps tendon where it attaches to the olecranon, to permit distraction of ulnohumeral joint by pulling it distally, further increasing visualization of the articular surface reduction through ligamentotaxis. Extreme flexion of the elbow can also aid further visualization of the distal posterior articular surface. After reduction of fracture fragment, it was fixed temporarily with smooth K-wire, and then with 4 mm cannulated cancellous screws either from the medial to the lateral or the lateral to the medial side. Finally, the distal fragment was approximated and anatomically reduced with the proximal humerus and temporarily fixed with smooth K-wire under direct visualization through both medial and lateral window. Temporary fixation was converted into a definitive fixation with orthogonal plate constructs – one plate on the dorsolateral surface and another plate on the medial column (3.5 mm locking plate, stainless steel, precontoured, and locking recon plate). Fracture fixation stability and elbow range of motion (ROM) were assessed intraoperatively. A RomoVac® drain was used before wound closure.

In the postoperative period, posterior Plaster of Paris (POP) slab was applied with the elbow in 90° flexion. Active exercises of shoulder, wrist, and fingers were initiated from the day of surgery. Posterior POP slab was changed every alternate day with the elbow in full extension and 90° flexion, until suture removal. After suture removal, the POP slab was removed and full active and assisted elbow motion was initiated. Regular followup was done every 4 weeks for 3 months, after which the patients were followed up at 6 months.

At each followup, clinical, functional, and radiological assessments were conducted by an orthopedic surgeon (different from the operating surgeon who participated in the study). Functional assessment was done using Mayo Elbow Performance Index (MEPI). Clinically, the range of elbow motion was measured using handheld goniometer.

The triceps muscle strength was assessed manually by surgeon using the uninjured arm as control. The patient was put in a prone position on the examination table with the arm in 90° abduction, the elbow in 90° flexion, and the forearm in neutral rotation. With one hand of surgeon supporting the patients' arm just above the elbow and another hand applying resistance on the dorsal surface of the patients' forearm, the patient was asked to extend the elbow against resistance. Muscle strength was graded as normal, good, and fair<sup>15, 16</sup>. Complications related to the surgery, if any, were also noted. Age and injury to surgical interval were analyzed with relation to the functional range of elbow motion<sup>17</sup> using Z-test for proportion.

Radiological assessment was conducted by elbow X-rays at the 4-week followup visits to assess fracture healing by filling of fracture gap and callus formation, heterotopic ossification, or any fracture displacement in anteroposterior and lateral views.

#### IV. Results

The mean duration of followup was 14.35 months (range 8–24 months). On clinical assessment, the mean elbow flexion was 134.55° [range 121–142°; Table 2]. The mean supination was 73.5° (range 65°–80°) and pronation was 74.3° (range 70–80°). The mean flexion deformity or extension loss was 5.45° (range 5°–18°). The mean arc of motion was 129.1°, and the mean ROM in C1, C2, and C3 type fractures were 138.57°, 133°, and 131°, respectively. The mean interval from injury to surgery was 2.95 days (range 1–6 days). Seventy four percent of the patients achieved functional range of elbow motion after surgery<sup>15</sup>. There was no significant difference in the range of motion of elbow in relation to age and injury to surgery interval.

Sixteen patients (80%) had normal muscle strength and four patients (20%) had good muscle strength. One patient had experienced ulnar neuropathy postoperatively, which recovered gradually over subsequent followups.

There was no evidence of heterotopic ossification in any of patients. Superficial infection was detected in three patients postoperatively; this resolved by oral antibiotics.

Functional outcome evaluation was done using MEPI, with a mean score of 95.75 points (range 80–100) leading to 18 excellent and 2 good results. The mean MEPI was 98.57, 94.44, and 93.75 points in C1, C2, and C3 type fractures, respectively.

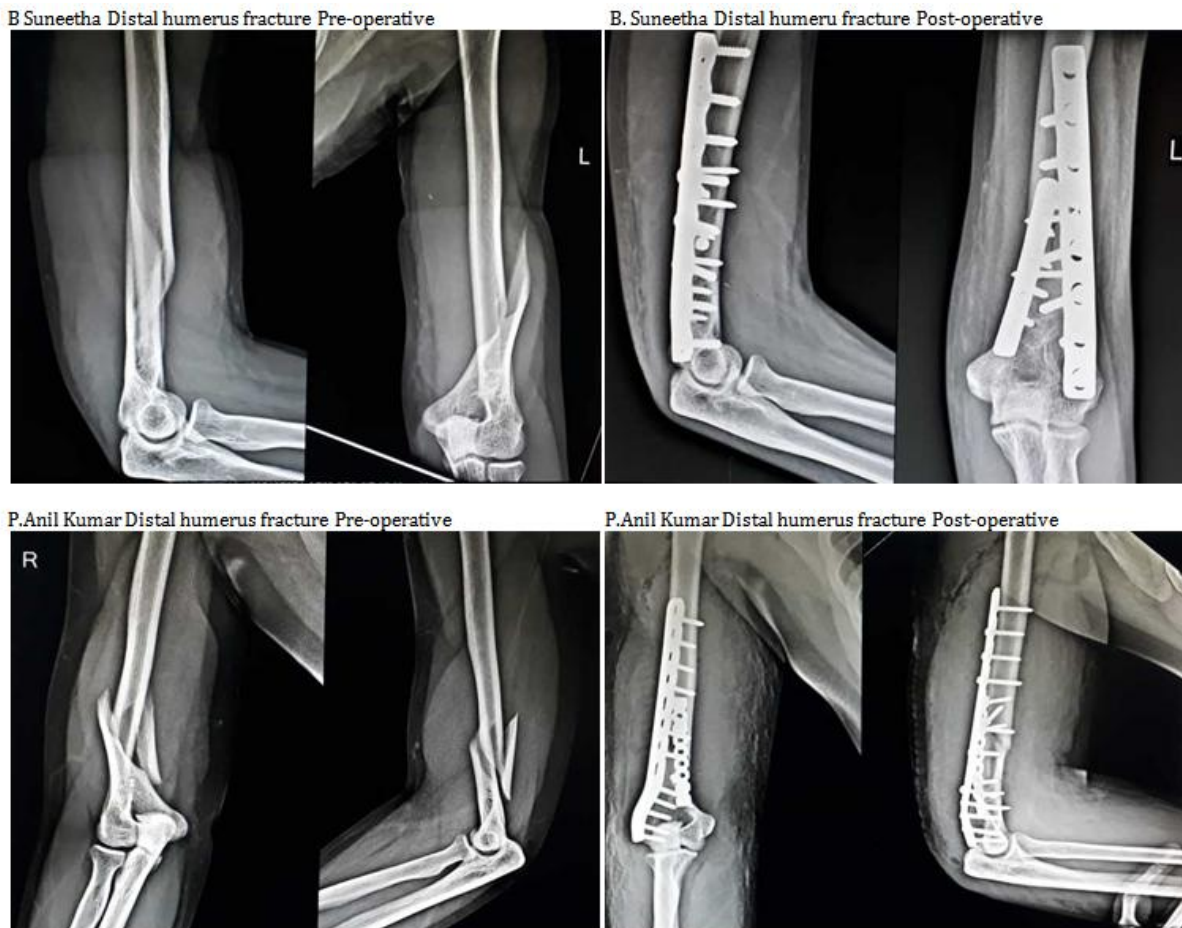
Triceps muscle strength grading (table 1)

NORMAL	GOOD	FAIR
Patient can extend elbow against resistance in available range	Patient can extend elbow against resistance, but “there is give way” to resistance at the end of range	Patient extends elbow with resistance

Clinical details of patients (table 2)

Age	AO TYPE	MODE OF INJURY	RANGE OF MOTION IN DEGREES	MOTION ARC IN DEGREES	MEPI
18	C2	RTA	0-140	140	100
24	C1	RTA	0-138	138	100
28	C1	Fall from height	0-140	140	100
26	C2	RTA	5-136	131	100
20	C1	Ground level fall	0-138	138	100
31	C3	RTA	5-136	131	100
42	C2	Ground level fall	5-134	129	85
44	C2	RTA	8-134	126	95
18	C1	Groundlevel fall	0-138	138	100
37	C2	RTA	10-126	116	90
55	C3	Ground level fall	10-130	120	95
62	C2	Ground level fall	15-121	106	90
53	C3	Fall from height	13-124	111	80
36	C2	RTA	18-132	114	100
49	C1	RTA	7-136	129	95
38	C3	Fall from height	0-134	134	100
32	C1	RTA	5-142	137	100
41	C1	RTA	0-138	138	95
19	C2	RTA	0-140	140	95
28	C2	RTA	8-134	126	95

On radiological assessment, all fractures were united, with a mean time to union of 10 weeks (range 8–14 weeks), with no more than 2mm step-off and more than 5° of malalignment.



## V. Discussion

The ideal approach for open reduction and internal fixation (ORIF) of intraarticular fractures of the distal humerus is still a topic of debate. Olecranon osteotomy through a posterior approach has been the gold standard for intraarticular fractures of distal humerus.<sup>18,19</sup> However, reconstruction of osteotomy may lead to delayed union, nonunion, and prominence of implant, which may require additional surgery.<sup>2-7</sup> Similarly, a triceps-splitting approach does not expose the articular surface adequately compared with other approaches as shown by Wilkinson and Stanley in their cadaveric study; this approach has a further disadvantage of direct muscle trauma leading to fibrosis and damage to intermuscular nerve branches, which can cause muscle weakness.<sup>20,21</sup> All these problem can be avoided by a triceps-sparing , “two-window” approach. As this approach utilizes a relatively bloodless plane and avoids direct trauma to the triceps muscle, it may limit the scar formation and reduce triceps muscle dysfunction postoperatively.

In literature we found that triceps-sparing approaches include, one in which triceps was reflected from olecranon along with forearm fascia from medial to lateral and another one in which triceps was kept intact on olecranon and fracture was accessed through medial and lateral window. In an extensive search of literature, we have found very few studies describing the functional outcomes and elbow motion following a paratricipital “two-window” approach for intraarticular distal humerus fracture<sup>9-13</sup>. In the present study, we used “two-window” approach for ORIF of distal humerus intraarticular fractures and reviewed the functional outcome.

Morrey *et al.* studied fifteen activities of daily living with respect to elbow motion and forearm rotation in a normal elbow, and concluded that 100° of elbow flexion and 100° of forearm rotation are required for most of the daily living activity<sup>26</sup>. Vasenet *et al.* studied<sup>12</sup> activity of daily living in one hundred elbows in normal population with respect to flexion and extension. By isolating the allowable ROM of the elbow and allowing for compensatory motions and strategies of the normal adjacent joints, the functional elbow ROM was established as 75–120° flexion.<sup>17</sup> In the present study, the mean elbow flexion was 134.55°, the mean forearm supination was 73.5°, the mean forearm pronation was 74.3°, and the mean arc of motion was 129.1°; are within the functional elbow ROM. Our results are comparable to other published studies<sup>10,12,22-24</sup>.

Furthermore, Illica *et al.* compared triceps sparing (in 16 patients) and triceps splitting approaches (in 23 patients) for extraarticular distal humerus fractures and concluded that elbow ROM and triceps strength were better with a triceps sparing approach compared with a triceps splitting approach.<sup>13</sup> Zhang *et al.* compared triceps

sparing with olecranon osteotomy approach in 67 patients with type C distal humerus fracture in an elderly population and concluded that triceps-sparing group has better functional outcomes, faster patient recovery, and lower complication rate, all without compromising visibility of articular surface or impairing fracture reduction during fixation.<sup>23</sup> In our study, the mean MEPI score was 95.75 point, with 18 excellent, 2 good, and no poor grade, which is consistent with other published series<sup>3,10,22,25</sup>. In sixteen patients, the muscle strength was normal and four patients had good muscle strength when compared to the uninjured arm.

Kundelet *al.* reported a rate of heterotopic ossification of up to 49% in their study<sup>27</sup> whereas in the present study, we did not experience any heterotopic ossification in any of the patients. Elbow stiffness is a common sequel after distal humerus fracture, often attributed to delayed initiation of rehabilitation.<sup>28</sup> In the present study, we were able to initiate active elbow flexion and extension motion in the patients very early as the continuity of the triceps muscle was maintained in the triceps-sparing approach. Early initiation of active motion could decrease the formation of periarticular fibrosis and adhesions.<sup>29</sup>

Our study demonstrates that the triceps sparing approach is easy to perform and provides an adequate exposure of articular fragments in all types of distal intraarticular fractures, even in AO type C3. However, this study reveals that while the elbow motion is reasonably good in AO type C1 and C2 fractures, it is poor in AO type C3 fractures. Because of limited number of patients with an AO type C3 fractures in our study, we cannot elucidate whether this lesser elbow motion was due to fracture complexity or the surgical approach. Thus, a triceps-sparing approach can be used for AO type C1 and C2 fracture with a high union rate and good functional outcome; however, the decision to use this approach for AO type C3 fracture should be made on intraarticular fracture comminution and the surgeon's familiarity with this approach.

Comparison with other studies. Table 3

Author	Approach	Fracture included according to AO	Mean flexion range	Extension loss (°)	MEPI Lowercase
Ali et al., 2008 <sup>12</sup>	Paratricipital	C1, C2, C3	120±8 (100-140)	6	84
Erpelding et al., 2012 <sup>10</sup>	Paratricipital	Type A, B, C (including C3)	115 (60-141)	9	91.5
Illical et al., 2014 <sup>13</sup>	Paratricipital	A2, A3	143±7	6	
Gosal and Singh 2015 <sup>24</sup>	Paratricipital	C1, C2	122(112-138)	7	93
Ek et al., 2008 <sup>22</sup>	Triceps reflecting	C1, C2, C3	110(90-135)	10	83
Fernandez et al., 2008 <sup>22</sup>	Triceps reflecting	C1, C2, C3	125.5 (112-135)	14.6	93.3
Zhang et al., 2014 <sup>23</sup>	Triceps reflecting	C1, C2, C3	124.52±10.52	16.45±5.51	87.71±4.78
Present study	Triceps sparing	C1, C2, C3	134.55 (121 <sup>0</sup> -142 <sup>0</sup> )	5.45 <sup>0</sup>	95.75

Our study had some limitations, including that of a small sample size and the lack of control groups, lack of objective muscle strength testing, small number of fracture types, especially AO type C3 and measurement of articular step and malalignment on plane x-rays, which would be better appreciated in computed tomography.

A further prospective, comparative multicentric study may be required to compare different approaches with an objective assessment of muscle strength in the management of distal intraarticular fracture of humerus (AO type C) in a larger group of patients with adequate representation of each fracture subgroup.

## VI. Conclusion

Open reduction and internal fixation of intraarticular distal humerus fractures with triceps-sparing approach provide adequate exposure with no adverse effect on triceps muscle strength and allows early initiation of elbow motion specially in type C1 and C2 fractures.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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