Original Article

Functional outcome of intraarticular distal humerus fracture fixation using triceps-sparing paratricipital approach

Vishal Yadav, Pulak Sharma, Ashish Gohiya

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 paratricipital approach which allows early elbow mobilization and preserving triceps strength.

Materials and Methods: Twenty five patients with intraarticular distal humerus fracture were operated using triceps-sparing paratricipital approach with orthogonal plate construct. There were 16 male and 9 female patients and average age was 42.16 years (range 23-65 years). The mechanism of injury was fall from height (*n* = 8), road traffic accident (*n* = 13) and ground level fall (*n* = 4). 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 13.58 months (range 6-22 months), mean elbow flexion was 121.08° (range 94°–142°) and mean motion arc was 114.92°(range 65°-140°). The mean MEPI score was 94.40 points (range 70–100) with 17 excellent, five good, and three fair results. The mean flexion deformity or extension loss was 6.16° (range 5°–15°).

Conclusion: Open reduction and internal fixation of intraarticular distal humerus fractures with triceps-sparing paratricipital 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, paratricipital surgical approach
MeSH terms: Fracture fixation, internal, humerus, bone plates, elbow joint

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.[1] 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.[2-7]

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Access this article online	
Quick Response Code:	Website: www.ijoonline.com
	DOI: 10.4103/0019-5413.193487

How to cite this article: Yadav V, Sharma P, Gohiya A. Functional outcome of intraarticular distal humerus fracture fixation using triceps-sparing paratricipital approach. Indian J Orthop 2016;50:595-601.

In 1972, Alonso-Llames described a "two-window" approach to treat supracondylar fractures in children where closed reduction had failed.[8] In 2003, this approach was expanded by Schildhauer *et al*.[9] 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.[9-13]

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

Materials and Methods

Twenty five patients with distal humerus intraarticular fractures AO type 13C were included in this prospective and observational study and internal fixation was done using paratricipital approach between January 2009 and January 2014. Mean age at the time of surgery was 42.16 years (range 23–65 years). Of the 25 patients, 16 (64%) were male and 9 (36%) were female. The modes of injury were due to fall from height (n = 8), road traffic accidents (n = 13) and ground level fall (n = 4). The fractures were classified according to AO/ASIF classification[14] on plain x-rays, 11 were of C1 type, 10 of C2 type, and 4 of C3 type. The mean interval from injury to surgery was 7.88 days (range 3–15 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 paratricipital approach using orthogonal plate constructs. All surgeries were performed by one senior author (AG) during the study period.

Operative procedure

Under general anesthesia 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 connected 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 [Figure 1a and b].

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,

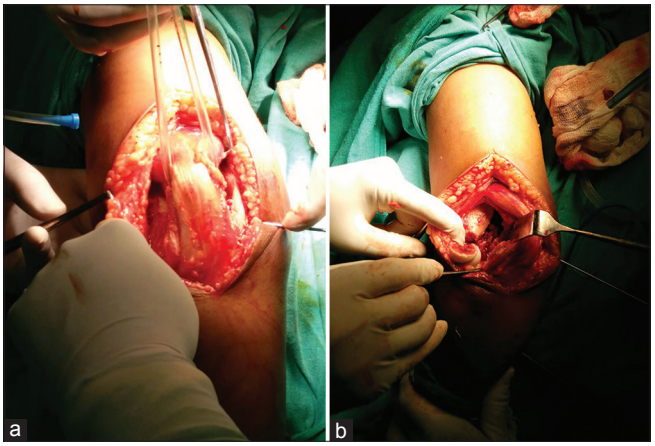

Figure 1: Peroperative photographs showing (a) Adequate visualization of distal humerus through lateral and medial windows. (b) Articular fracture fragment seen through medial window

precontoured, and locking recon plate). Fracture fixation stability and elbow range of motion (ROM) were assessed intraoperatively. A Romo Vac® 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 other 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 [Table 1].[15,16] 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[17] 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.

Results

The mean duration of followup was 13.58 months (range 6–22 months). On clinical assessment, the mean elbow flexion was 121.08° [range 94–142°; Table 2]. The mean supination was 76.6° (range 60°–80°) and pronation was 77.4° (range 70–80°). The mean flexion deformity or extension loss was 6.16° (range 5°–15°) [Figure 2a-d]. The mean arc of motion was 114.92°, and the mean ROM in C1, C2, and C3 type fractures were 130.09°, 121.10°, and 96.25°, respectively. The mean interval from injury to surgery was 7.88 days (range 3–15 days). Sixty eight percent of the patients achieved functional range of elbow motion after surgery.[15] There was no significant difference in the range of motion of elbow in relation to age and injury to surgery interval [Tables 3 and 4].

Twenty one patients (84%) had normal muscle strength and four patients (16%) had good muscle strength. Two patients 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 two patients postoperatively; this resolved by oral antibiotics.

Functional outcome evaluation was done using MEPI, with a mean score of 94.40 points (range 70–100) leading to 17 excellent, five good, and three fair results. The mean MEPI was 99.0, 94.5, and 81.25 points in C1, C2, and C3 type fractures, respectively.

Table 1: Grading of the strength of triceps muscle

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

Table 2: Clinical details of patients

Age (in years)/ sex	AO type	Mode of injury	Range of motion (in degrees)	Motion arc (in degrees)	MEPI
23/male	C2	RTA	0-140	140	100
47/male	C1	RTA	5-138	133	100
38/female	C1	Fall from height	5-142	137	100
50/male	C2	Fall from height	8-122	114	100
29/male	C1	Fall from height	0-138	138	100
61/female	C2	Ground level fall	10-110	100	85
36/female	C1	Ground level fall	0-134	134	100
41/male	C3	Fall from height	15-80	65	70
48/male	C2	RTA	10-120	110	100
31/male	C3	RTA	10-90	80	70
44/male	C1	RTA	5-125	120	100
26/male	C1	RTA	0-140	140	100
65/male	C2	RTA	8-110	102	90
52/female	C1	Fall from height	0-120	120	95
37/male	C2	RTA	8-130	122	100
28/male	C3	RTA	10-110	100	100
33/female	C2	RTA	0-130	130	100
49/female	C1	Ground level fall	5-110	105	95
56/male	C2	RTA	10-130	120	100
36/female	C1	Fall from height	0-130	130	100
27/male	C3	RTA	10-105	95	85
40/female	C2	RTA	5-125	120	100
35/male	C1	Fall from height	12-135	122	100
57/male	C1	Fall from height	8-120	112	100
65/female	C2	Ground level fall	10-95	84	70

RTA=Road traffic accident, MEPI=Mayo Elbow Performance Index

Figure 2: Clinical photographs showing (a-d) Functional range of motion at 6 months followup

Table 3: Functional outcome in relation to age of patient (*Z*-score: 0.978, not significant)

Age group in years	Functional range present	Functional range absent	Total patients
<40	10	3	13
>40	7	5	12

Table 4: Functional outcome in relation to injury to surgery interval (*Z*-score: 0.497, not significant)

Injury to surgery interval in days	Functional range present (patients)	Functional range absent (patients)	Total (patients)
<7	8	3	11
>7	9	5	14

On radiological assessment, all fractures were united, with a mean time to union of 10.2 weeks (range 8–14 weeks), with no more than 2 mm step-off and more than 5° of malalignment [Figures 3-5].

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.[18,19] However, reconstruction of osteotomy may lead to delayed union, nonunion, and prominence of implant, which may require additional surgery.[2-7] 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.[20,21] All these problem can be avoided by a paratricipital, "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.[9-13] In the present study, we used this paratricipital "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.[26] Vasen *et al*. studied 12 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.[17] In the present study, the mean elbow flexion was 121.08°, the mean forearm supination was 76.6°, the mean forearm pronation was 77.4°, and the mean arc of motion was 114.92°; are within the functional elbow ROM. Our results are comparable to other published studies [Table 5].[10,12,22-24]

Furthermore, Illical *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.[13] 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.[23] In our study, the mean MEPI score was 94.40 point, with

17 excellent, five good, three fair, and no poor grade, which is consistent with other published series.[3,10,22,25] In 21 patients, the muscle strength was normal and four patients had good muscle strength when compared to the uninjured arm.

Kundel *et al.* reported a rate of heterotopic ossification of up to 49% in their study;[27] 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.[28] 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 paratricipital approach. Early initiation of active motion could decrease the formation of periarticular fibrosis and adhesions.[29]

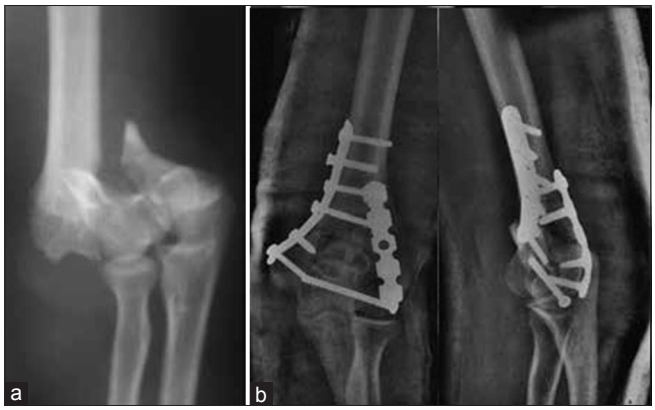

Figure 3: (a) Preoperative x-ray of elbow joint showing C1 fracture. (b) Postoperative X-ray of elbow joint anteroposterior and lateral views showing medial and lateral plates fixation for C1 fracture

Our study demonstrates that the triceps sparing paratricipital 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 paratricipital 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.

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 appreciate in computed tomography.

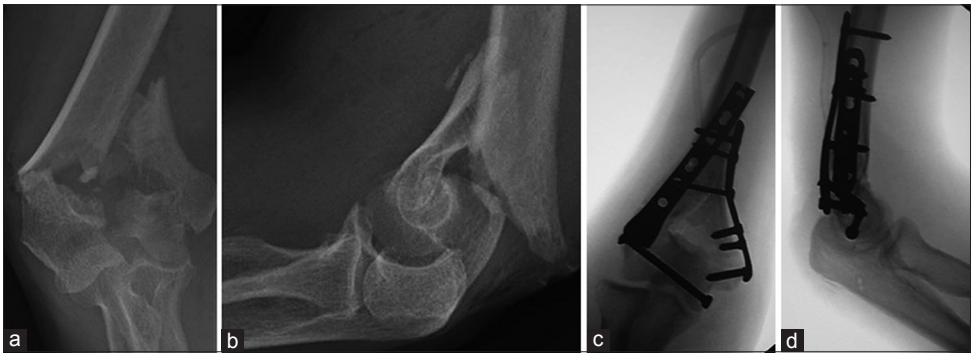

Figure 4: Preoperative X-ray of elbow joint (a) anteroposterior view (b) lateral view showing C2 fracture. (c) Postoperative X-ray anteroposterior view (d) lateral view showing medial and lateral plates

Table 5: Comparison with other published study

Author	Approach	Fracture included (according to AO)	Mean flexion (°) (range)	Extension loss (°)	MEPI
Ali *et al.*, 2008[12]	Paratricipital	C1, C2, C3	120±8 (100-140)	6	84
Erpelding *et al.*, 2012[10]	Paratricipital	Type A, B, C (including C3)	115 (60-141)	9	91.5
Illical *et al.*, 2014[13]	Paratricipital	A2, A3	143±7	6	
Gosal and Singh 2015[24]	Paratricipital	C1, C2	122 (112-138)	7	93
Ek *et al.*, 2008[22]	Triceps reflecting	C1, C2, C3	110 (90-135)	10	83
Fernández *et al.*, 2013[25]	Triceps reflecting	C1, C2, C3	125.5 (112-135)	14.6	93.3
Zhang *et al.*, 2014[23]	Triceps reflecting	C1, C2, C3	124.52±10.52	16.45±5.51	87.71±4.78
Present study	Paratricipital	C1, C2, C3	121.08 (94-142)	6.16	94

MEPI=Mayo Elbow Performance Index

Figure 5: Preoperative X-ray of elbow (a) anteroposterior view (b) lateral view showing C3 type fracture Postoperative X-ray of elbow joint (c) anteroposterior view (d) lateral view showing medial and lateral plates position and reduction

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.

Conclusion

Open reduction and internal fixation of intraarticular distal humerus fractures with triceps sparing paratricipital 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.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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