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Original Article

Paratricipital two window approach for complex intraarticular distal humerus fractures: A prospective analysis of 27 patients

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ABSTRACT

Background: To investigate the utility and complications of paratricipital 2 window approach for complex intra articular distal humerus fractures (AO/OTA type C).
Methods: Between December 2012 and September 2016 , 27 patients (male-14, female-13) having mean age of 39 years (range, 22–62 years) with closed intra articular fracture (AO/OTA 13 type C) were surgically managed using paratricipital 2 window approach. Fractures were fixed as per AO principles. All patients were followed up for 21 months (range, 12–28 months) prospectively. Functional outcome was measured using Mayo Elbow Performance Score (MEPS) and complications were observed. Student t-test, Pearson co-relation coefficient and Kruskal Wallis test used for statistical evaluation.
Result: All cases unite by the end of 3 months. Mean flexion achieved was 120° and extension lag was 10°. Mean arc of motion was 111°. Mean pronation and supination was 70° and 77° respectively. MEPS and motion arc were weak negatively co- related with surgical delay and advancement in age. Postoperative transient ulnar nerve palsy and heterotrophic ossification (HO) was noted in 3.7% cases and infection occurred in 7.4% cases. Hardware prominence noted in 11.1% cases. Mean MEPS was 82. MEPS was excellent in 18.5%, good in 62.9%, fair in 11.1% and poor in 7.4% cases.
Conclusion: Paratricipital 2 window approach for these fractures had good functional outcome with fewer complications. We advocate paratricipital 2 window approach when dealing with these complex fractures particularly, in type C1 and type C2.

Introduction

Fractures of distal humerus are on increasing trends since last few decades.[1] Besides fracture geography and fixation techniques, exposure of elbow joint is crucial to reconstruct anatomy. Both columns of distal humerus and articular surface are principally approached via posterior exposure.[2] Approaches like olecranon osteotomy, triceps-reflecting anconeus pedicle, triceps reflecting (Bryan and Morrey's approach[3]), triceps splitting (Campbell's approach) and paratricipital (Alonso-Llames,[4] triceps sparing) have been described in literature with pros and cons of each.

Olecranon osteotomy which is commonly used for such fractures has limitations, mainly nonunion, loss of osteotomy reduction, symptomatic hardware, increased surgical time and possible postoperative restricted mobilization.[5–8] Triceps splitting has very limited articular visualization which makes it undesirable for such injuries.[8] Triceps-reflecting anconeus pedicle and triceps reflecting approaches have also reported triceps weakness, triceps avulsion.[2] Alonso Llames,[4] in 1972 described triceps sparing approach with medial and lateral windows for supracondylar fracture in children which was further reshaped by Schildhauer et al.[9] to approach intraarticular fractures of distal humerus in adults. Triceps muscle and insertion is not disrupted in this approach, permitting early active range of motion. Only disadvantage of this approach is the constrained visualization of the articular surface of the distal humerus, therefore often not adequate in complex fractures.[10]

So far only limited literature is available to look for the utility of this approach especially in complex distal humerus fractures. We conducted a prospective study on adults to look for functional outcome of paratricipital approach in closed intra-articular fracture of distal humerus (AO/OTA 13 type C) and possible complications.

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We hypothesizes that functional outcome is proportional in young adults (≤40 years) and middle aged group (41–65 years). We also hypothesized that surgical delay after injury and advancing age yield poor outcome.

Methods

After ethical committee and departmental review board clearance, this prospective study was conducted between December 2012 and September 2016 in Department of Orthopaedics, GSVM Medical College, Kanpur, India. Initially, a total of 48 patients admitted with intraarticular communited fracture of distal humerus (AO 13-C) were identified. Of them, 13 patients were excluded for 4 cases of open fractures, 7 multiple fractures of ipsilateral extremity, 1 pathological fracture and 1 neglected fracture.

Paratricipital approach was conducted by two senior trauma surgeons for all the patients. In two patients of type C3, the approach had to be converted into olecranon osteotomy to ease reduction and fixation; therefore they were also excluded from this study. For the rest 33 patients, 6 were lost for follow-up soon after surgery and thus excluded too. The minimal inclusion follow-up period was set at 12 month. Finally a total of 27 patients (male = 14, female = 13) with the mean age of 39 years were evaluated. Motor vehicle accidents caused the most injuries (44.4%). For additional analysis, patients were divided into difference age groups of ≤40 years ($n = 16$) *vs.* >40 age ($n = 11$) and different fractures type groups of C1 ($n = 13$), C2 ($n = 8$) and C3 ($n = 6$). Detailed information of patients is listed in Table 1.

Surgical fixation was done under general anaesthesia in lateral decubitus position with arm support and haemostasis achieved using tourniquet in all patients. Prophylactic antibiotic (Cefuroxime 1.5 g) was given in all cases. Signed informed consent was taken from all patients about fracture type, approach used and possible complications.

Surgical technique

A midline posterior incision was used with slight lateral bent on olecranon tip to avoid weight-bearing zone. Ulnar nerve was identified first and then release of ligaments of Struthers and medial intermuscular septum was done to transpose the ulnar nerve. Anterior transposition of ulnar nerve was done in all cases in our series. Dissection was done on medial side along intermuscular septum posterior border to expose posterior-medial border of humerus. After creating medial window, posterior lateral humerus was approached by lifting lateral border of triceps from lateral intermuscular septum. Dissection was carried out proximally as required; but if more proximal dissection was required, radial nerve was identified and retracted. Whole triceps muscle was elevated along posterior surface of humerus by connecting these two windows (as described by Schildhauer et al.[9]). This exposes the posterior humeral shaft and fractured fragments (Fig. 1). Fracture reduction was done after clearing the debris by direct and indirect manipulation under fluoroscopy guidance. Fracture sites were stabilized with orthogonal platting, i.e. one plate on medial site and the other on posterolateral side, roughly perpendicular to each other as per AO principle.

Postoperative care

The wound was closed under negative suction drain which was removed after 48 h. Elbow was immobilized in 90° for initial two days. After drain removal, range of motion (ROM) exercises were encouraged and gradually increased aiming to achieve elbow flexion up to 90° by the end of 2 weeks and full ROM by 6 weeks. Patients were regularly followed up at 6 week, 12 week and thereafter every three months for radiological and functional assessment.

Outcome measurement

ROM was measured manually using a goniometer. Functional assessment was done using Mayo Elbow Performance Score (MEPS). Radiological assessment was done using X-rays in follow-up visits. Articular step-off of >2 mm or malalignment of >5° in any plane was considered as malunion.

Statistical analysis

Data were summarized as mean and standard deviation. Continuous variables were compared using two-tailed student *t*-test. Pearson correlation coefficient test was used to assess correlation strength; Kruskal-Wallis test to establish any relationship between fracture type and motion arc or functional outcome. A p value less than 0.05 was considered for the level of significance, for all analysis (SPSS version 22).

Table 1
General data of 27 patients with intraarticular communited fracture of distal humerus.

Parameter	*n* (%)
Male/Female	14/13
Age (years)	39
Subgroup based on age (years)	
≤40	16 (59.3)
>40	11 (40.7)
Side of fracture	
Right	19 (70.3)
Left	8 (29.7)
Mechanism of injury	
Motor vehicle accident	12 (44.4)
Simple fall	8 (29.6)
Fall from height	3 (11.1)
Fall from bicycle	4 (14.8)
AO fracture type	
C1	13 (48.1)
C2	8 (29.6)
C3	6 (22.2)

Fig. 1. Creating two windows inparatricipital approach.

Results

Mean follow-up of patients was (21 ± 6) months (range, 12–28 months). Mean surgical delay was (3 ± 1) days (range, 1–7 days). All fractures united by three months (Figs. 2 and 3). The mean flexion, extension lag and flexion/extension motion arc achieved was respectively 120°, 10° and 111°. Others are shown in Table 2.

ROM

The final ROM was dependent upon initial fracture subtype, confirmed by Kruskal-Wallis test ($H = 11.69$, $p = 0.002$), with type C3 accompanying the poorest ROM. Extension lag ($H = 11.50$, $p = 0.003$) also showed significant difference in fracture subtypes. No articular step-off of >2 mm or malalignment of >5° was observed in any plane.

The younger age group (≤40 years) obtained significantly higher ROM compared with middle age group (>40 years; 118.7° ± 14.5° *vs.* 100.4° ± 27.9°, $t = 2.23$, $p = 0.0348$). Pearson correlation coefficient for ROM with advancing age ($R = -0.52$) and surgical delay ($R = -0.379$) showed negative weak correlation.

MEPS

Mean MEPS was 81.6, 88.8 for type C1, 81.9 for type C2 and 65.8 for type C3 respectively. MEPS was excellent in 18.5% cases, good in 62.9%, fair in 11.1% and poor in 7.4% (Table 2). Kruskal-Wallis test showed that the functional outcome (MEPS) was also dependent on initial fracture type ($H = 11.83$, $p = 0.002$).

Comparison between younger and middle-aged groups, mean MEPS showed statistically insignificant results (81.9 ± 126 vs. 81.4 ± 14, $t = 0.099$, $p = 0.921$). Pearson correlation coefficient also revealed negative weak correlation for MEPS with advancing age ($R = -0.072$) and delay in surgery after injury ($R = -0.121$).

Complications

Postoperative transient ulnar nerve neuropraxia occurred in one patient (3.7%) with type C3 fracture, which completely recovered

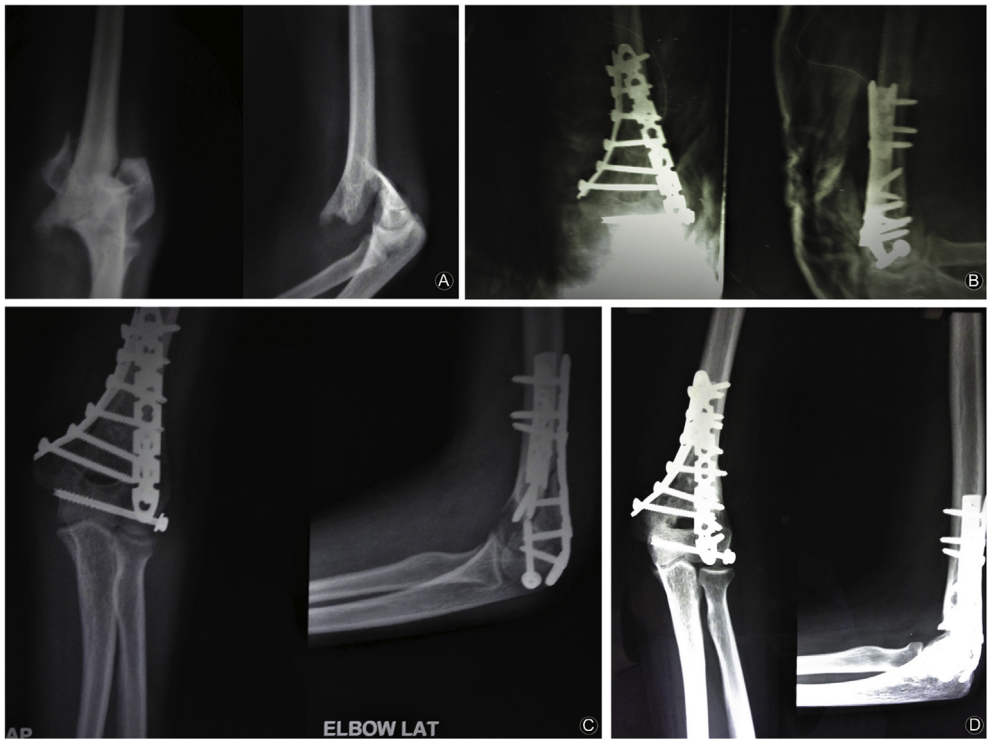

Fig. 2. (A, B) preoperative and immediate postoperative X-rays of type C2 fracture; (C) 1 month after surgery; (D) union of fracture site at 3 month follow-up.

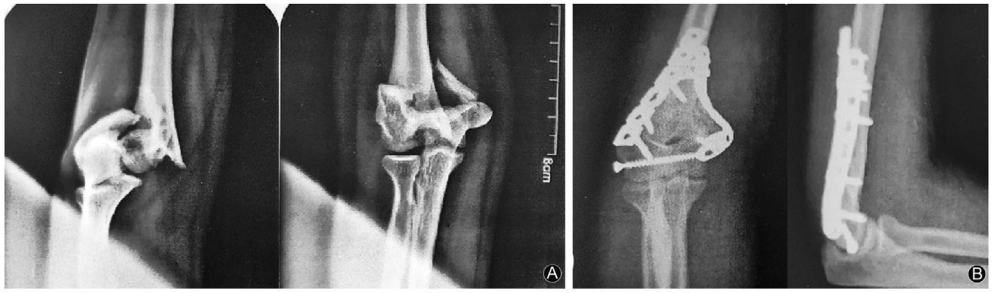

Fig. 3. (A) Preoperative and (B) 3 month postoperative X-ray of Type C1 fracture showing union.

Table 2
Functional outcome of 27 patients for paratricipital approach.

Parameter	Type of fracture			
	C1 ($n = 13$)	C2 ($n = 8$)	C3 ($n = 6$)	Total ($n = 27$)
Age (years)	39.6 ± 11.9	40.6 ± 12.7	34.3 ± 13.7	38.7 ± 12.3
Surgical delay (d)	2.6 ± 1.3	2.4 ± 1.5	3.5 ± 1.3	2.7 ± 1.4
Surgical time (min)	89.7 ± 9.0	99.2 ± 6.6	121.6 ± 4.4	99.2 ± 13.3
Flexion (°)	126.5 ± 9.0	126.2 ± 10.6	100 ± 14.1	120.5 ± 15.2
Extension lag (°)	6.1 ± 4.2	6.9 ± 3.7	21.7 ± 7.5	9.9 ± 8.0
Arc of motion (flexion/extension, °)	120.4 ± 11.8	121.2 ± 11.9	78.3 ± 20.1	111.3 ± 22.5
Pronation (°)	73.7 ± 2.3	69.2 ± 4.4	65.6 ± 6.2	70.4 ± 5.0
Supination (°)	79.7 ± 3.5	76.2 ± 5.6	72.5 ± 4.6	77.0 ± 5.3
Arc of (pronation/supination, °)	153.4 ± 5.5	145.5 ± 9.0	138.1 ± 10.3	147.4 ± 9.7
Mayo elbow performance score				
Mean	88.8 ± 7.9	81.9 ± 8.4	65.8 ± 13.6	81.6 ± 12.9
Excellent (≥90)	4 (14.8)	1 (3.7)	0	5 (18.5)
Good (75–89)	9 (33.3)	7 (25.9)	1 (3.7)	17 (62.9)
Fair (60–74)	0	0	3 (11.1)	3 (11.1)
Poor (≤59)	0	0	2 (7.4)	2 (7.4)

Data are expressed as mean ± SD or *n* (%).

by two months. Heterotrophic ossification occurred in one case (3.7%). Infection occurred in two cases (7.4%), one in type C2 group and the other in type C3 group, which recovered with debridement and prolonged antibiotic therapy. Implant prominence was the main complication which attacked three cases (11.11%).

Discussion

The fundamental advantage of paratricipital two window approach is intact extensor mechanism so that rehabilitation can be started the earliest. Furthermore if surgeon find difficult to attain articular reduction, the approach can be easily converted to olecranon osteotomy or Bryan & Morrey triceps reflecting approach.[11] There are scanty publications on the feasibility of paratricipital approach regarding functional outcome.

Erpelding et al.[12] reported 62.5% excellent, 29.2% good and 13.3% fair outcome in distal humeral articular fractures. Though majority of their patients were type C fracture (17 out of 24 patients) but they also included type A and B fractures. The median motion arc in their study was 130° for type C1, 131° for type C2 and 75° for type C3. We utilized a goniometer to quantify the motion arc in our study. We noted that the mean motion arc (flexion/extension) was 120° in type C1, 121° in type C2 and 78° in type C3. Type C3 fracture had the poorest outcome in comparison to types C1 and C2, probably because of fracture geometry. Also Ali et al.[13] reported a mean of 120° ± 8° flexion and 6° extension in their series for type C fracture. But they did not report the achieved motion in individual fracture subtypes.

We achieved comparable good to excellent result (81.4%, Table 2) regarding MEPS with the literature (Table 3).[12–14] Also we found forearm rotational movements are not a concern which goes accordance to literature.[15,16] Comparison of MEPS with two different age groups i.e. ≥40 years and <40 years found statistically insignificant difference. However other authors reported a higher MEPS in younger age group.[15] The possible reason could be more type C3 patients in the young age group in our series caused by high energy trauma and resulting in poor score.

Some authors predicated a negative impact on muscle strength in triceps splitting or reflecting approach as a consequence of weakened reattachment or resultant fibrosis of direct trauma.[3,17] But in this paratricipital approach triceps attachments and muscle belly is not altered, allowing prompt active motion of elbow.

Table 3
Overview and comparability with other published articles.

Study	Case No., mean age (years) and follow-up period (months)	Rate of union and functional outcome	Complications	Comment
Erpelding et al.[12]	$n = 24$ Age = 47 Follow-up = 27	100% MEPS = 91.5	No infection or HO, 1 postoperative ulnar nerve palsy and 3 stiffness release	Having a high healing rate and good restoration of elbow function with some limitation in type C3.
Ali et al.[13]	$n = 22$ Age = 32.5 Follow-up = 33	100% MEPS = 84.	1 infection, 1 hardware prominence, and no postoperative ulnar nerve palsy or HO	Satisfactory results but not recommended for type C3 humerus fracture.
Illical et al.[14]	$n = 23$[a] Age = 32 Follow-up = 11.7	100% DASH score[b] = 14.55 for symptom, 19.64 for work, 16.25 for sports.	No postoperative neurological deficit	Better elbow ROM and triceps strength compared with triceps-splitting approach. Functional outcome similar in triceps splitting and paratricipital approach.
Our study	$n = 27$ Age = 38.7 Follow-up = 21.1	100% MEPS = 81.6.	1 postoperative ulnar nerve palsy, 1 HO, 2 infection and 3 hardware prominence	Good in selected patients, especially type C1 and C2 humerus fractures.

MEPS: Mayo elbow performance score; HO: heterotopic ossification; ROM: range of motion.
[a] Only type A2 and A3 humerus fractures were included.
[b] DASH (disabilities of the arm, shoulder, and hand) score ranges from 30–150 (30 items scored 1–5 for each). Lower score implies better outcome.

Though we did not report on muscle strength, we did not found any clinically relevant difference in power in comparison to contralateral side. Comparably other investigators also delineate no significant power loss in injured and uninjured elbow.[12,13]

We routinely transfer ulnar nerve anteriorly in all our patients. Though there is no strong evidence for support, this is our preference to avoid any possible chance of friction between nerve and hardware during elbow ROM. Currently a randomized controlled trial titled "*A multicentre, randomized trial of simple decompression versus anterior transposition of the ulnar nerve for acute, displaced fractures of the distal humerus treated with plate fixation*" is going on and results are awaited.[18]

Surgical approach contribution in heterotopic ossification development is still debatable. Chen et al.[19] noted 12% cases of heterotopic ossification in olecranon osteotomy approach compared to negligible in triceps sparing. Hong et al.[20] noted that timing and duration of surgery along with fracture dislocation were independent risk factors but, did not comment upon the role of approach. In our study, only one patient of type C3 fracture develops heterotopic ossification. Possible cause may be high velocity motor vehicle accident resulting in considerable swelling and ecchymosis around elbow leading to delay in surgery. These all have positive co-relation with heterotopic ossification development. Our results exhibited that paratricipital two window approach is adaptable, especially in type C1 and C2 humerus fractures with large fragments. However there are difficulties in more complex type C3 fracture but can easily be overcome by converting into more extensile approaches with ease.

Our study has limitations too. First, only a few number of patients were include, mainly in type C3 and control group was lack for outcome comparison. Secondly, the follow-up period was not long enough, only short to middle term. Thirdly, the outcome was evaluated using scoring systems rather than objective functional tests. Fourthly, we excluded geriatric patients, so conclusion on age versus outcome is not viable. Lastly, we did not objectively note the loss of extension strength. Though our prime objective was to assess the functional outcome, we still considered it as a limitation.

In our study we concluded that paratricipital two window approach is a good approach with few complications. Exposure was satisfactory for articular reduction and fixation, particularly in subtype C1 and C2 humerus fractures. Though we are not declaring that this is a versatile approach for all distal humerus fracture, it can restore elbow function and achieve high healing rate in selected cases. In more complex fracture type C3 humerus fractures, decision should be made considering surgeons familiarity with approach. The benefit with this approach lies that it can be easily converted to more extensile approaches with ease in cases where reduction cannot be achieved or assessed intraoperatively.

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Ethical statement

Ethical committee and departmental review board clearance has been approved before conduction of this study.

Conflicts of interest

The authors declared no conflicts of interest.

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