



Original Research Article

A PROSPECTIVE COHORT STUDY TO COMPARE EFFECTIVENESS BETWEEN THE PARATRICIPITAL APPROACH AND THE CHEVRON OLECRANON V OSTEOTOMY APPROACH FOR TREATMENT OF DISTAL HUMERUS FRACTURES

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ABSTRACT

Background: Distal humerus fractures are commonly managed by open reduction and internal fixation through a posterior approach. The olecranon osteotomy offers the widest view of the articular surface but adds a second bony injury, while the paratricipital approach preserves the extensor mechanism at the cost of a smaller view. Hence we compared both approaches to find out which is better. The aim and objective is to compare a modified paratricipital (MPT) approach with the chevron olecranon osteotomy (COO) approach for distal humerus fractures.

Materials and Methods: In this prospective comparative cohort study, thirty patients were operated through the MPT approach and 30 through the COO approach. Operative time, blood loss, incision length, intraoperative fluoroscopy use, range of motion (ROM) at 12 weeks, Mayo Elbow Performance Score (MEPS) at 6 months, time to union and complications were compared.

Results: The groups were similar in age, sex and mechanism of injury. The modified paratricipital approach gave shorter surgery duration, less blood loss, a smaller incision and better elbow motion at 12 weeks than the chevron olecranon osteotomy, and mean functional scores at 6 months were comparable. Chevron olecranon osteotomy had higher overall risk of complications like infection and implant complications.

Conclusion: The modified paratricipital approach is a reasonable alternative to osteotomy for distal humerus fractures if used along with intraoperative fluoroscopy.

Keywords: Distal humerus fracture, Paratricipital approach, Olecranon osteotomy, Chevron osteotomy, Mayo Elbow Performance Score.

INTRODUCTION

Distal humerus fractures are relatively uncommon and account for about 2% of adult fractures.^[1,2] In

young adults they usually follow high-energy trauma, and many extend into the elbow joint.^[1] Good results depend on restoring the articular anatomy, achieving stable fixation and starting early movement, since the

elbow stiffens quickly after injury.^[2] For this reason, most displaced fractures in adults are treated by open reduction and internal fixation.^[2]

The posterior approach is the standard route to the distal humerus, and it can be developed in several ways.^[3,4] The olecranon osteotomy gives the widest view of the distal articular surface, but it creates a second fracture that must heal and its fixation can cause symptoms, loss of reduction or non-union.^[3] The paratricipital approach leaves the triceps insertion intact and works through medial and lateral windows on either side of the muscle.^[5] It avoids the osteotomy and allows early rehabilitation, but the view of the joint surface is more limited.^[6]

Studies comparing the two approaches have not reached agreement on which gives better outcomes.^[4,5,7,8] To improve the view without an osteotomy, we modified the paratricipital approach by elevating the medial or lateral part of the triceps insertion subperiosteally from the olecranon, while leaving at least half of the insertion attached. This study compares the outcomes of this modified paratricipital (MPT) approach with those of the chevron olecranon osteotomy (COO) in adults with distal humerus fractures.

MATERIALS AND METHODS

Study design and setting: Written informed consent for participation and surgery was obtained from every patient.

Eligibility Criteria

Inclusion Criteria

- Age between 18 and 60 years
- Fracture of the distal humerus requiring operative fixation
- Fresh fracture, with injury less than 3 weeks old
- Willingness to give written informed consent and attend follow-up

Exclusion Criteria

- Pathological fractures
- Open (compound) fractures
- Fractures with associated neurovascular injury

Fracture Classification: Fractures were classified on preoperative anteroposterior and lateral radiographs of the elbow using the AO/OTA classification for the distal humerus (segment 13). Type 13-A fractures are extra-articular, type 13-B are partial articular fractures in which part of the joint surface remains attached to the shaft, and type 13-C are complete articular fractures in which the joint surface is separated from the shaft. Type C fractures are further graded as C1 (simple articular, simple metaphyseal), C2 (simple articular, multifragmentary metaphyseal) and C3 (multifragmentary articular). Computed tomography was used where the articular fracture pattern was unclear on plain radiographs.

Allocation: Patients were counselled about both approaches, including their expected advantages and drawbacks. Allocation to the MPT group or the COO group was then made by the operating surgeon. The

study was non-randomised, and 30 patients were treated in each group.

Sample size: The sample size was calculated for comparing two independent means using the formula $n = 2(Z_{1-\alpha/2} + Z_{1-\beta})^2/d^2$, where n is the number of patients per group, $Z_{1-\alpha/2} = 1.96$ for a two-sided significance level of 5%, $Z_{1-\beta} = 0.84$ for 80% power, and d is the standardised difference (effect size) between groups. With these values, 30 patients per group gives 80% power to detect a standardised difference of 0.73 between the two approaches. A total of 60 patients, 30 in each group, was therefore enrolled. The calculation was carried out using the SciPy library in Python.

Surgical technique: Modified paratricipital approach. The posterior paratricipital (Alonso-Llames) approach was used.^[5,6] Through a posterior midline incision, a medial (ulnar) window was developed after identifying and protecting the ulnar nerve, and a lateral (radial) window was developed between the triceps and the lateral intermuscular septum. To improve the view of the joint, the medial or the lateral part of the triceps insertion was elevated subperiosteally from the olecranon, never both sides. At least half of the insertion was left attached, so the extensor mechanism was never fully detached, unlike the triceps-reflecting approach.^[9,10] The elevated part was repaired back to the olecranon at closure. Fluoroscopy was used to check fracture lines that could not be seen directly.

Chevron olecranon osteotomy approach. Through the same posterior incision, the anconeus was elevated laterally and the ulnar head of flexor carpi ulnaris medially to expose the olecranon. A chevron osteotomy with its apex pointing distally was made with an oscillating saw and completed with an osteotome, and the olecranon fragment was reflected proximally with the triceps.^[11] After fixation of the distal humerus, the osteotomy was fixed with tension band wiring with K-wires, an intramedullary screw or a plate.^[11]

In both groups, the distal humerus was fixed with precontoured medial and lateral locking plates.

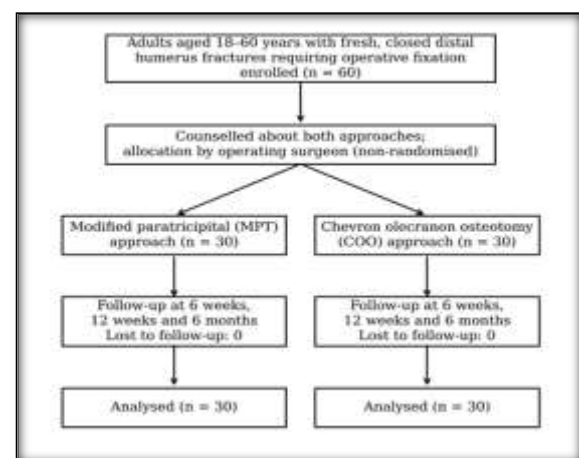


Figure 1: Flow of patients through the study. MPT, modified paratricipital approach; COO, chevron olecranon osteotomy.

Postoperative care and follow-up: The elbow was immobilised in a posterior splint for about 14 days until suture removal. Active and active-assisted range of motion (ROM) exercises were then started. Patients were reviewed at 6 weeks, 12 weeks and 6 months for clinical and radiological assessment. Elbow ROM was recorded with a goniometer at 12 weeks, and functional outcome was assessed with the Mayo Elbow Performance Score (MEPS) at 6 months. Union was defined as bridging callus across the fracture on two orthogonal radiographs with no pain at the fracture site. Infections, implant-related problems, non-union, ulnar neuropathy and heterotopic ossification were recorded.

Outcome measures: The intraoperative outcomes were operative time, estimated blood loss, incision length and the number of fluoroscopy (C-arm) exposures. The postoperative outcomes were ROM at 12 weeks, MEPS at 6 months, time to union and complications.

Statistical analysis: Continuous variables are presented as mean $\pm$ standard deviation and were compared with the unpaired Student's t-test, or the Mann–Whitney U test where data were not normally

distributed. Categorical variables are presented as numbers and were compared with the chi-square test, or Fisher's exact test where any expected cell count was below 5. A two-sided P value below 0.05 was taken as statistically significant. Patient-level data for MEPS, time to union and fluoroscopy exposures were not available for analysis, so these outcomes are reported as group means only and were not tested statistically.

RESULTS

All 60 patients completed follow-up and were included in the analysis [Figure 1]. The two groups were similar at baseline [Table 1]. The mean age was 45 ± 8.2 years in the MPT group and 45 ± 7.5 years in the COO group ($P = 1.000$). There were 21 men (70%) in the MPT group and 18 men (60%) in the COO group ($P = 0.417$). The injury followed a fall in 12 patients and a road traffic accident in 18 patients in the MPT group, compared with 15 and 15 in the COO group ($P = 0.436$).

Table 1: Baseline characteristics of the two groups

Characteristic	MPT group (n = 30)	COO group (n = 30)	P value
Age (years), mean $\pm$ SD	45 ± 8.2	45 ± 7.5	1.000a
Male, n (%)	21 (70.0)	18 (60.0)	0.417b
Female, n (%)	9 (30.0)	12 (40.0)	
Mechanism: fall, n (%)	12 (40.0)	15 (50.0)	0.436b
Mechanism: road traffic accident, n (%)	18 (60.0)	15 (50.0)	

MPT, modified paratricipital approach; COO, chevron olecranon osteotomy; SD, standard deviation. aUnpaired t-test. bChi-square test.

Operative time was 30 minutes shorter in the MPT group (110 ± 11.5 vs 140 ± 14.5 min, $P < 0.001$). Blood loss was lower (220 ± 60 vs 310 ± 74 ml, $P < 0.001$), and the incision was shorter (10.5 ± 1.1 vs 13.2 ± 1.12 cm, $P < 0.001$) (Table 2, Figure 2). The mean number of fluoroscopy exposures was 10 in the MPT group and 15 in the COO group.

At 12 weeks, mean elbow ROM was $130^\circ \pm 10^\circ$ in the MPT group and $120^\circ \pm 15^\circ$ in the COO group, a statistically significant difference ($P = 0.004$). At 6 months, the mean MEPS was 85.3 in the MPT group and 75.1 in the COO group. Mean time to union was

10.2 weeks and 12.1 weeks respectively. These two outcomes were reported as group means and were not tested statistically.

Infection occurred in 3 patients in the COO group and in none in the MPT group ($P = 0.237$). Implant-related complications, mainly prominent or symptomatic olecranon hardware, occurred in 3 patients in the COO group and none in the MPT group ($P = 0.237$). Ulnar neuropathy or heterotopic ossification was seen in one patient in each group ($P = 1.000$). No fracture or osteotomy non-union occurred in either group.

Table 2: Intraoperative and postoperative outcomes

Outcome	MPT group (n = 30)	COO group (n = 30)	P value
Operative time (min)	110 ± 11.5	140 ± 14.5	$< 0.001a$
Blood loss (ml)	220 ± 60	310 ± 74	$< 0.001a$
Incision length (cm)	10.5 ± 1.1	13.2 ± 1.12	$< 0.001a$
Fluoroscopy exposures, mean	10	15	—c
ROM at 12 weeks (degrees)	130 ± 10	120 ± 15	0.004a
MEPS at 6 months, mean	85.3	75.1	—c
Time to union (weeks), mean	10.2	12.1	—c
Infection, n (%)	0 (0)	3 (10.0)	0.237b
Implant-related complications, n (%)	0 (0)	3 (10.0)	0.237b
Ulnar neuropathy / heterotopic ossification, n (%)	1 (3.3)	1 (3.3)	1.000b
Non-union, n (%)	0 (0)	0 (0)	—

Values are mean $\pm$ SD unless stated otherwise. MPT, modified paratricipital approach; COO, chevron

olecranon osteotomy; ROM, range of motion; MEPS, Mayo Elbow Performance Score. aUnpaired t-test.

bFisher's exact test. cReported as group means only; not tested statistically.

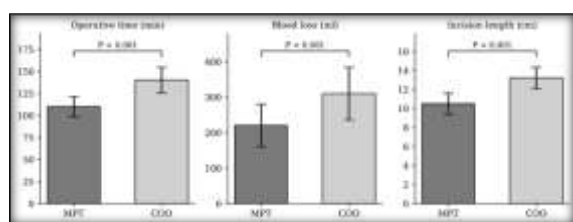


Figure 2: Intraoperative outcomes by approach (mean ± SD). MPT, modified paratricipital approach; COO, chevron olecranon osteotomy.

DISCUSSION

Both approaches are widely used for distal humerus fractures, yet there is still no clear agreement on which gives better results with fewer complications.^[6,7] In this study, 30 patients were treated through each approach, and the groups were comparable in age, sex and mechanism of injury. The modified paratricipital approach was faster, caused less blood loss and needed a shorter incision. It also gave better elbow motion at 12 weeks. Mean functional scores at 6 months were higher and mean time to union was shorter in the MPT group, although these outcomes were not tested statistically.

The shorter operative time, lower blood loss and smaller incision are expected, as the paratricipital approach avoids making and then fixing an osteotomy. Jamali et al. also reported shorter operative time with an extensor-sparing approach.^[12] and the meta-analysis by Jeong et al. found a longer operative time with olecranon osteotomy.^[7] Early recovery of elbow motion probably reflects the fact that the extensor mechanism was left largely attached, which allows active exercises to begin without protecting an osteotomy.

All infections and implant-related complications occurred in the osteotomy group, but with three events in each category the difference did not reach statistical significance. This pattern agrees with earlier reports. Complications of tension band wiring of the olecranon, particularly prominent and symptomatic hardware, are well described.^[13] and higher rates of hardware problems after osteotomy have been reported in the meta-analysis by Jeong et al. and the systematic review by Feinstein et al.,^[7,14] Gainor et al. and Ring et al. reported delayed healing and non-union after olecranon osteotomy, especially with transverse cuts, with non-union rates as high as 30% in some series.^[15,16] We had no osteotomy non-union, which may reflect the use of the chevron rather than the transverse osteotomy, as the chevron cut is more stable and has a larger area for healing.^[14]

Mean MEPS at 6 months was not lower in the MPT group, which is in keeping with Jeong et al., Feinstein et al. and Athanaselis et al., who found no meaningful difference in MEPS between the two approaches.^[7,14,17] The main concern with the

paratricipital approach is the limited view of the joint surface. Elmadag et al. and McKee et al. reported poorer function after triceps-preserving or triceps-lifting approaches for complex intra-articular fractures compared with osteotomy.^[18,19] In our technique, the medial or lateral part of the triceps insertion was elevated from the olecranon to improve the view, similar in principle to the triceps hemi-peel described by Grogan et al.,^[10] and the expanded paratricipital approach described by Cho et al.,^[6] Cho et al. showed that the expanded approach is suitable for C1, C2 and selected C3 fractures.^[6] Fluoroscopy was used to check reduction of fracture lines that could not be seen directly, which helped achieve articular reduction where the direct view was limited. In our technique, at least half of the triceps insertion was always left attached and the elevated part was repaired back to the olecranon, so the extensor mechanism was never fully detached. The better ROM at 12 weeks in the MPT group supports this.

Our findings support the modified paratricipital approach as a less invasive option, with functional results at 6 months that were not worse than those of the osteotomy in this series. The choice of approach should still be guided by the fracture pattern, the surgeon's experience and patient factors. For highly comminuted articular fractures, where direct visualisation of the whole joint surface is essential, the osteotomy remains a valuable option.

This study has several limitations. Allocation was not randomised and was made by the operating surgeon, which may have introduced selection bias. The distribution of AO fracture types in each group is not reported, so it cannot be confirmed that the groups were matched for fracture complexity. Patient-level data for MEPS and time to union were not available, so these outcomes could only be described and not compared statistically. The sample size was small, and the study was not powered to detect differences in uncommon complications such as infection. Follow-up was limited to 6 months, so late problems such as post-traumatic arthritis could not be assessed. The study was carried out at a single centre, which may limit how widely the results apply.

CONCLUSION

The modified paratricipital approach had a shorter operative time, less blood loss, a smaller incision and better elbow motion at 12 weeks than the chevron olecranon osteotomy, and no hardware-related complications occurred with it in this series. Mean functional scores at 6 months were not lower with the modified approach, although this outcome could not be compared statistically. Although it gives a smaller view of the joint surface, the modified paratricipital approach, used with intraoperative fluoroscopy, is a reasonable alternative to olecranon osteotomy for distal humerus fractures. Larger randomised studies with complete functional data are needed to confirm these findings.

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