Comparative Analysis of Results of Paratricipital Approach and Olecranon Osteotomy in Non Comminuted Distal Humerus Fractures - A Retrospective Study Conducted at a Tertiary Hospital in Kolkata

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ABSTRACT

BACKGROUND

Intercondylar humerus fractures and low transcondylar type fractures of distal humeral often require surgical exposure and anatomical reduction of the articular surface as well as stabilization of the medial and lateral columns of the distal humerus. Traditionally, these injuries have been treated surgically with various extensor mechanism-disrupting surgical approaches. These approaches have often led to delayed union or non-union of the olecranon, triceps weakness, and osteotomy-related prominent implants. To avoid these problems, various extensor mechanism-sparing approaches that provide bicolumnar exposure of the distal part of the humerus have been described, including triceps-splitting and reflecting techniques. The paratricipital approach was developed to avoid the problems of olecranon osteotomy approach for non comminuted distal humerus fractures.

The purpose of this study was to compare the paratricipital approach with olecranon osteotomy and evaluate their effects on the functional outcomes of intercondylar fractures of the distal humerus managed with open reduction and internal fixation (ORIF) by reviewing 38 cases of intercondylar distal humerus fractures surgically managed with either of the approaches during 2015 - 2017.

METHODS

The retrospective study was conducted at our institution, R.G. Kar Medical College, Kolkata from May 2015 to May 2017. OA type C1 and C2 fractures were included in the study. Type C3 fractures were excluded from the study. Distal humeral open reduction and internal fixation (ORIF) was performed with either orthogonal or parallel plate constructs in 38 patients, where paratricipital approach was used in 21 patients and olecranon osteotomy was done for 17 patients.

RESULTS

Patients in the paratricipital approach group seems to have better range of motion in terms of flexion and extension. Moreover, mayo elbow performance score (MEPS) of the paratricipital group is better than that of olecranon osteotomy group, even more so in younger age groups.

CONCLUSIONS

We found that ORIF via the paratricipital approach would confer better functional outcomes for simple intra-articular distal humerus fractures in patients of all age groups.

KEYWORDS

Distal Humerus Fracture, Paratricipital, Olecranon Osteotomy

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BACKGROUND

Intercondylar fractures of the distal humerus (AO/ASIF type C) amount to 1 % of all factures in adults. These fractures are fairly difficult to treat and have an unpredictable outcome. Restoration of satisfactory elbow function requires anatomic reconstruction of the articular surface and stable fixation of the fractured fragments to allow early and full rehabilitation.[1] As a result, many favour open reduction and internal fixation (ORIF). As in all forms of surgery, exposure and access to the structure are critical.[2-5] Various techniques have been described for approaching the posterior distal humerus, and controversy exists regarding which approach is optimal in minimising complications and enhancing function.[3,6-8]

Operative treatment of intra-articular distal humeral fractures is well described. The goal of surgery is to gain stable fixation that allows early elbow range of motion and functional restoration.[9] The operative approach and type of stabilization depends primarily on the fracture pattern and displacement of the fracture fragments.[7] Uni condylar intra-articular distal humeral fractures can be treated with fixation of one column through a limited approach.[7] However, intercondylar fractures require accurate reduction of the articular surface of the distal humerus and stabilization of the lateral and medial columns. The typical surgical exposure for operative stabilization of bi columnar fractures is the olecranon osteotomy approach.[7] This is an extensive exposure that provides complete posterior visualization and access to the distal humerus.[7] Various techniques for olecranon osteotomies have been described, with the Chevron technique being most popular. The potential complications of olecranon osteotomy include delayed union, non-union, malunion, diastasis of osteotomy, and prominent or loosened hardware. Complications of olecranon osteotomy also make revision or conversion to a total elbow arthroplasty more difficult. Other exposures to the distal humerus include triceps tendon splitting[3] or triceps mechanism reflection at the musculotendinous junction Alternative exposures have been described. Olson et al. recommended a trans tricipital approach, which is like the triceps-splitting exposure but includes a continuation of the split into the periosteal layer of the olecranon and proximal ulna.[10] With an osteotome, each half of the tricipital insertion is elevated with a small portion of the olecranon. The triceps-reflecting anconeus pedicle approach for distal humeral fractures and non-union involves release of the entire extensor mechanism from the olecranon and proximal ulna with proximal reflection.[11] In total elbow arthroplasty, Bryan and Morrey [3] described a triceps-sparing posterior exposure with lateral reflection of the extensor mechanism after medial release of the triceps and excision of the cap of the olecranon. A similar approach in total elbow arthroplasty is the osteo anconeus flap, which preserved the continuity of the attachment of the triceps brachii muscle with a wafer of bone from the reflected extra-articular portion of the olecranon and with the lateral fascia of the forearm.[12] The paratricipital approach is an extensor sparing approach that can be an effective alternative to the conventional extensile approaches in C1 and C2 intercondylar humerus fractures.

Aim

To determine whether the paratricipital approach can be used as an alternative to olecranon osteotomy approach in non comminuted intercondylar humerus fractures.

Objectives

1. To compare the functional outcomes of intercondylar humerus fractures operated by paratricipital approach and olecranon osteotomy approach.
2. To compare the results of intercondylar humerus fractures operated by olecranon osteotomy approach and paratricipital approach in terms of mayo elbow performance score.

METHODS

The retrospective study was conducted at our institution, R.G. Kar Medical College, Kolkata by reviewing surgical records and following up the patients from May 2015 to May 2017. Distal humeral open reduction and internal fixation (ORIF) was performed with either orthogonal or parallel plate constructs in 38 patients.

Consent

Informed consent was taken from each patient, and ethical clearance was sought from the ethical committee of our institution. It was approved vide letter number RGK/2017/Sp25.

Sampling

All patients with AO type C1 and C2 were included in the study except those mentioned below. Since all the cases in the above-mentioned time frame were included, no specific formula was used to calculate sample size.

Inclusion Criteria

AO type C1 and C2 distal humerus fractures.

Exclusion Criteria

AO type C3 fractures and open fractures were excluded from our study. Thirteen (13) patients were excluded from our study because of one of the following reasons: surgical approach used was one other than the ones included in the study (two elbows), preoperative triceps avulsion (two elbows), previous elbow surgery (four elbows), comminuted fracture of distal humerus (AO classification 13 - C3) (four elbows), open fracture (one elbow). The exclusion criteria were chosen based on their ability to influence functional outcomes.

Assigning Cases to Groups

Cases were randomly assigned to each group matching similar age, sex, and fracture configuration.

A Short Description of the Approaches we Followed

Paratricipital approach

The patient is placed on the operating table in the prone or lateral decubitus position. The injured arm is placed on a support allowing at least 90° of elbow flexion. The entire limb is prepared circumferentially and draped free in the operative field. In our experience, a tourniquet is avoided because of the potential for limitation of distal triceps elevation and further insult to the traumatized soft tissues. A midline posterior incision between the lateral and medial brachial cutaneous nerves is performed, curving laterally around the olecranon. It is continued about 5 to 8 cm distal to the olecranon tip. The fascia overlying the triceps brachii is identified, split in the midline, and elevated with the dermis and subcutaneous tissue, creating two fasciocutaneous flaps. Dissection is continued to the lateral and medial triceps borders at their respective interfaces with the posterior aspects of the intermuscular septae. In this way, the triceps muscle is separated from the posterior surface of the intermuscular septae. The posterolateral humeral shaft is approached by elevating the triceps muscle from the posterior periosteum and by retracting it medially. Distally and laterally, the dissection can be continued anterolateral to the anconeus muscle, thereby preserving its innervation and blood supply. Medially, the ulnar nerve is identified and exposed proximally in the posterior compartment. When more proximal exposure of the humerus is required, the ulnar nerve can be followed further until it pierces the intermuscular septum coming from the anterior compartment. Distally, it is released from the cubital tunnel and dissected to its first branch. Medial paratricipital dissection along the posterior border of the intermuscular septum exposes the posteromedial aspect of the distal humerus. Connection of the medial and lateral dissections by mobilization and elevation of the triceps muscle from the fracture and posterior humeral periosteum allows visualization of the entire posterior distal humerus. It is important to be aware of the arterial and venous perforators cephalad to the medial and lateral epicondyles, which connect the anterior and posterior compartment vessel systems. An arthrotomy of the elbow joint is performed posterior to the medial and lateral humeroulnar ligaments after elevating the anconeus off the posterior surface of the lateral column with the triceps and posterior fat pad. Fracture reduction can then be performed after cleaning of the fragments off debris, and with indirect manipulation under fluoroscopic control in two planes.

The principles behind our method of stabilization were to maximize fixation in the distal fragments and to maximize fracture stability at the supracondylar level. These principles were satisfied with the technique of parallel plate fixation, which permits insertion of at least four long screws through the plate and across the distal fragments from one side to the other. These screws interdigitate, thereby creating a fixed-angle structure and greatly increasing the stability of the construct.

Olecranon Osteotomy Approach

A uniform technique was used for the creation of the olecranon osteotomy. A longitudinal posterior surgical incision was performed, and the ulnar nerve was identified and mobilized. The triceps muscle was elevated from the medial and lateral intermuscular septae. When present, the "bare area" of the olecranon was visualized after division and elevation of the medial and lateral capsular attachments along the olecranon process. The bare area is typically devoid of articular cartilage and corresponds to the deepest portion of the semilunar notch. If intramedullary screw fixation for osteotomy stabilization was planned, the proximal ulna was predrilled appropriately. Beginning on the dorsal surface directly posterior to the bare area, a thin oscillating saw was used to create the "V" shaped chevron osteotomy in, but not through, the subchondral bone. Creation of an osteotomy perpendicular to the long axis of the ulna was the goal in each case. Irrigation of the saw blade was used to avoid thermal necrosis. Thin osteotomies were then inserted, and the osteotomy completed by fracturing through the osteochondral surface. This latter manoeuvre leaves an irregular, chondral/cancellous surface that can accurately interdigitate at the time of fixation, assisting with the reduction and stability of the osteotomy. The osteotomized portion of the olecranon and the triceps muscle were reflected proximally, exposing the distal humeral articular surface. The radial nerve was not routinely identified, but that option was available depending on the proximal extent of the fracture and application of implants. During reduction and stabilization of the distal humerus, tissue desiccation was avoided by periodic sterile saline irrigation of the surgical area. Fixation of the osteotomy was performed after fixation and radiographic assessment of the distal humeral articular reconstruction. An anatomic articular reduction of the osteotomy was the objective in all cases.

Principles of Reconstruction

Interfragmentary compression was obtained both between articular fragments and at the metaphyseal level using large bone clamps that provided compression during insertion of the screws. Fully threaded screws inserted in this manner provide maximum thread purchase in the distal fragments. Additional compression at the metaphyseal level results from slight under-contouring of the plates and the use of dynamic compression holes in the plates.

Postoperative Care

Immediately after closure, the elbow was placed in a bulky non compressive Jones dressing with an anterior plaster slab to maintain the elbow in extension, and the upper extremity was kept elevated. The initial rehabilitation was planned according to the extent of soft-tissue damage. The Jones dressing was removed after two days and an elastic non-constrictive sleeve was applied over an absorbent dressing placed on the wound. A physical therapy program including active and passive motion was then initiated. All patients were permitted active use of the hand and were instructed not to lift (or push or pull) anything heavier than a glass of water or a telephone receiver for the first six weeks. No form of external protection, such as a cast or brace, was used by

any patient; only a sling was provided for comfort and was used by the patients as needed.

Mayo Elbow Performance Score

The Mayo elbow performance score (MEPS) or Mayo elbow performance index (MEPI) is an objective score to evaluate the limitations of the activities of daily living (ADL) caused by elbow pathology. This specific test uses 4 subscales:

1. Daily function.
2. Pain.
3. Stability.
4. Elbow range of motion.

MEPS is used to measure the outcome of different treatments subjected to the elbow joint or its components, for example: the difference in prognosis between open and closed fractures when operated.

Evaluation

MEPS ranges from a score of 0 to 100 with the following interpretations

- < 60 implies poor.
- 60 - 74 implies fair.
- 75 - 89 implies good.
- 90 - 100 implies excellent.

Part 1: Pain

How severe and how frequent is the pain?

- 45 points for patients with no pain.
- 30 points for patients who have mild pain.
- 15 points for moderate pain.
- 0 indicates severe pain.

Part 2: Range of motion

The patient is asked to flex the extended elbow:

- 20 points for more than 100° flexion.
- 15 points for range of motion between 100° - 50°
- 5 points for flexion of 50° or less.

Part 3: Stability

- 10 points if the elbow is considered stable.
- 5 points indicate mild instability.
- 0 points for unstable elbow.

Part 4: Activity of Daily Living

5 points each based on the following activities of daily living:

- Combing hair
- Being able to maintain personal hygiene
- Eating
- Being able to put buttons in a shirt or wear shoes.

Characteristics	Values
Sex (male : female)	16 : 22
Mean age(years)	44.5 (16 - 77)
Mean follow up time (months)	24 (18 - 26)
Type of fractures	
C1	21
C2	17
ORIF by paratricipital approach	21
ORIF by olecranon osteotomy approach	17

Table A. Statistics of Different Characteristics of the Study

Figure 1. Paratricipital Approach Giving a Good Exposure to the Condyles

Follow Up

Patients were serially followed up at intervals of 2 weeks, 6 weeks, 3 months, 6 months 1 year and 2 year. Serial X-rays were taken at these intervals. Mean time for bony union was found to be 12 weeks (Range: 7 - 18 weeks).

Statistical Analysis

We performed the statistical analysis with Statistical Package for Social Sciences (SPSS) for Windows 13.0. To confirm the normal distribution of data, normality tests were conducted; with all values being denoted as mean ± standard deviation. The significance level of this study was set at two-sided $\alpha = 0.05$.

RESULTS

Patients in the paratricipital approach group seems to have better range of motion in terms of flexion and extension. Moreover, MEPS of the paratricipital group is better than that of olecranon osteotomy group, even more so in younger age groups.

Age Group (years)	ORIF Approach	N	Flexion	Extension	Pronation	Supination	MEP Score
> 60	OO	3	120.7 ± 20.1	22.9 ± 16.3	68.8 ± 15.1	69.6 ± 23.4	76.7 ± 20.4
	PT	3	123.4 ± 19.3	10.7 ± 10.3	67.7 ± 14.7	72.5 ± 16.7	82.4 ± 17.1
40 - 60	OO	4	121.3 ± 13.3	13.9 ± 11.1	68.6 ± 12.1	70.7 ± 12.4	82.4 ± 18.7
	PT	6	122.7 ± 11.3	11.4 ± 10.7	70.7 ± 11.1	73.8 ± 9.6	83.3 ± 15.3
< 40	OO	10	122.7 ± 14.7	9.8 ± 4.5	69.6 ± 20.3	72.5 ± 11.1	84.9 ± 12.8
	PT	12	121.3 ± 18.8	10.7 ± 11.9	70.9 ± 11.5	72.2 ± 12.2	82.4 ± 17.3
Total	OO	17	121.3 ± 13.1	14.3 ± 12.1	68.2 ± 11.1	71.3 ± 13.5	82.8 ± 18.4
	PT	21	121.5 ± 12.4	10.9 ± 13.7	70.5 ± 12.1	72.1 ± 10.2	84.5 ± 15.5

Table 1. Follow-up Data Based on Age for Paratricipital Approach and Olecranon Osteotomy Approach

Note: PT- Paratricipital; OO-Olecranon Osteotomy; Flex-Flexion; Ext-Extension; Pro-Pronation; Sup-Supination; MEP Score: Mayo Elbow Performance Score

Poor results in both groups could be attributed to poor bone quality, and in cases where mechanism of injury was as a result of more violent trauma. All fractures had united without the need of revision surgery. For patients having a poor outcome, they were made to undergo a strict and supervised physiotherapy regime.

Age (years)	Approach	MEP Score Rating (% of Total Patients) Excellent Good Fair Poor
< 40	PT	50 30 20 0
	OO	25 12 50 12
40 - 60	PT	36 45 18 0
	OO	40 40 10 10
> 60	PT	50 33 16 0
	OO	43 56 0 0
Total	**PT**	**45 36 18 0**
	OO	**38 41 14 6**

Table 2. MEP Score Rating for Paratricipital Approach and Olecranon Osteotomy Approach

Figure 2. ORIF by Olecranon Osteotomy Approach

Figure 3. ORIF by Paratricipital Approach

DISCUSSION

To provide a good functional outcome, it is essential to perform an accurate reduction of the articular surface of the distal humerus along with adequate reconstruction of both the columns. This would enable a person to provide early mobility by providing adequate stability.

The goals of operative management of distal humerus fractures include anatomic articular reduction, rigid fixation and restoration of the anatomic axes allowing early unrestricted range of motion. Visualization of the distal humeral articular surface is difficult because of the overlying elbow extensor mechanism and the intact olecranon. Direct visualization is enhanced with the creation of an olecranon osteotomy or by mobilization of the extensor mechanism from the proximal ulna.[1] Although the olecranon osteotomy has demonstrated improved visualization of the distal humeral articular surface compared with other techniques in cadaver studies,[8] previous clinical reports have identified delayed and/or non-union in approximately 10 % of patients and prominent hardware in approximately 25 %.[9] This has resulted in additional surgical procedures for non-union repair and the removal of prominent internal fixations about the proximal ulna.[9]

Credited to MacAusland, the trans-olecranon approach was popularized by Cassebaum.[5] Direct visualization of the fracture is enhanced by mobilizing the extensor mechanism, which is further enhanced by osteomatising the olecranon process, as it has been demonstrated in cadaveric experiments.[13] Olecranon osteotomy has been reported to have inherent complications that range from increasing surgical time, delayed union, non-union (10 %), malunion, prominent hardware (25 %), secondary procedures for removal of hardware (13 %), and the problem of non-union repair[14,15]

The most frequently cited complications associated with olecranon osteotomy are non-union and symptomatic prominent hardware.[16,17] Henley[17,18] noted a 23 % complication rate related to olecranon osteotomy. Difficulties with union were identified in 10.3 % of patients, with remaining complications associated with symptomatic internal fixation.[17] All the complications in the study occurred in those osteotomies that were fixed with K-wire tension band technique.[18] McKee et al. noted that 27 % required re-operation for removal of symptomatic internal fixation. Gofton et al.[18] reported non-union in 2 of 22 olecranon osteotomies. One osteotomy was secured with an intramedullary screw and tension band wiring and the second was secured with K-wires and tension band technique.[18] John and Rosso noted non-union in two osteotomies out of 49 patients, and they advised chevron olecranon osteotomy and tension band wiring for fixation of osteotomies to overcome the problem. Holdsworth[11] observed three delayed unions of olecranon osteotomies, but all three were transverse osteotomies as compared to chevron osteotomies.

An olecranon osteotomy was used in the operative management of C-type distal humerus fractures to allow adequate articular visualization, enabling accurate articular reductions.[9] A few factors must be considered when deciding on an operative plan including the location of open wounds and the potential need to acutely convert to total elbow arthroplasty in the active geriatric patient.[9] Fracture complexity also guides to which approach is used, with the olecranon osteotomy approach being more commonly used in the elderly. Post-operative X-rays were done to check reduction. The results of this study demonstrated a high percentage of satisfactory distal humeral articular reductions. This suggests that the olecranon osteotomy enables accurate reduction of the distal humeral articular surface, including those with increasing fracture comminution (type C3 patterns) but C3 fractures were not

included in our study. The authors, however, understand that the accuracy of radiographic measurements of articular congruity may be suboptimal,[19] and the reader should recognize this as a limitation of this study. Other authors have demonstrated no difference in articular reductions with both the olecranon osteotomy and extensor mechanism mobilization approaches.[1,2,5,19] In separate non randomized studies, McKee et al.[20] noted no significant articular mal reductions in either the triceps-splitting or osteotomy approaches for C-type distal humerus fractures. No information, however, was given regarding the distribution of C1, C2, or C3 injuries or, as in this study, whether an increasing number of C3 injuries were managed with the olecranon osteotomy.[9] The routine use of an olecranon osteotomy approach in the management of an open distal humerus fracture has been questioned. Injury to the triceps at the meta-diaphyseal region of the distal humerus has been noted by previous authors[20] and has been corroborated by this study. Incorporating the triceps defect into the surgical approach, typically a modified triceps-splitting exposure, has been suggested as a method of limiting surgical trauma and improving functional outcome.[20] Coles et al.[9] mentioned that the use of an olecranon osteotomy in 42 open fractures, of which nearly half demonstrated substantial injury to the triceps, did not result in any complications related to osteotomy union. They felt that that the presence of an open injury does not preclude the use of the olecranon osteotomy, particularly in the setting of significant articular comminution.[9]

Macko et al. reported elbow symptoms due to prominent K-wire in 15 cases (75 %) out of their 20 cases and skin breakdown in four (20 %).[21] In a study of 88 fractures of the olecranon, Horne et al. reported that 66 (75 %) patients required removal of the wire within one year because of pain and 7 % patients had non-union.[22] Ring et al. reported a non-union rate of 30 % of transverse olecranon osteotomy in surgical fixation of fractures of distal humerus.[23] Gainor et al. observed that 27 % of their patients necessitated removal of hardware because of symptoms related to wires and septic olecranon bursitis.[24]

Chao et al. concluded ORIF via the triceps-sparing approach that confers inferior functional outcomes for intercondylar distal humerus fractures in patients over the age of 60 years, for whom the olecranon osteotomy approach may be a better choice.[14] But in cases of patients less than 60 years of age, more specifically for those aged less than 40, either approach confers satisfactory outcomes.

The extensor mechanism-sparing approach has several advantages over previously described surgical approaches. We concur with Jamali et al.[25] that it decreases operative time. Additionally, the risks of perioperative or postoperative complications are reduced as it avoids the olecranon osteotomy and its stabilization. Postoperatively, an early aggressive functional treatment can be started, including active range of motion and muscle-strengthening exercises in flexion as well as extension. Early exercises of the triceps mechanism, including passive range of motion and dynamic splinting, may help to prevent triceps weakness and adhesions, which are reported to occur in 11 to 29 percent of patients.[11,25] Also, early functional treatment can minimize elbow stiffness.

In our study, all patients of paratricipital approach regained normal strength by 12 months while Askew et al.[26] reported loss of strength of triceps in all patients with olecranon osteotomy or triceps-splitting approach.

CONCLUSIONS

The paratricipital approach does not allow as much visualization as the olecranon osteotomy approach to the distal humerus, particularly the distal articular surface but, we were able to achieve anatomic articular reductions in AO/ASIF type C1 and C2 distal humerus fractures, indirectly by manipulating the supracondylar components with their attached articular condyles. For such properly indicated cases, the paratricipital exposure also reduces the risk of perioperative and postoperative complications. Therefore, the paratricipital posterior approach to the distal humerus is a good alternative in carefully selected patients. The present study compared the paratricipital approach with olecranon osteotomy regarding their effects on the functional outcomes of non comminuted intercondylar fractures of the distal humerus managed by open reduction and internal fixation. 38 cases of intercondylar distal humerus fractures were reviewed where they were surgically managed with either of the two approaches. We found that open reduction and internal fixation by the paratricipital approach confer a better functional outcome for intercondylar distal humerus fractures in patients of all ages but even more in younger population.

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