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Clinical comparison of management of intra-articular distal humerus fractures with two surgical approaches; TRAP vs Olecranon osteotomy

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Abstract

Background: The aim of this study is to evaluate and compare the functional outcomes of patients with intra-articular distal humerus fractures treated with triceps-reflecting anconeus pedicle (TRAP) and olecranon osteotomy.

Methods: Thirty three patients with intra-articular distal humerus fractures were retrospectively analysed. TRAP approach was used in 17 patients (10 males, 7 females; mean age 35.9 years, range 17-70), and olecranon osteotomy in 16 patients (11 males, 5 females; mean age 34.4 years, range 18-62). Fractures were classified using the AO/ASIF classification. Functional results were evaluated with the Mayo elbow performance score (MEPS) and the Disabilities of Arm, Shoulder and Hand (DASH) questionnaire score.

Results: The overall mean arc of elbow motion was 108° (range 70°-140°) in the TRAP group, whereas that of the olecranon osteotomy group was 102° (range 70°-130°). There were no significant differences noted between the two groups in terms of mean MEPS and DASH scores ($p=0.318$, $p=0.236$, respectively). The overall complication rate was 41.17% in the TRAP group and 56.25% in the olecranon osteotomy group.

Conclusion: Intra-articular distal humerus fractures mandates surgical fixation for best functional outcomes. Both TRAP and olecranon osteotomy approaches can be used in the treatment of intra-articular distal humerus fractures. Both approaches yields no significant difference in clinical and functional results for intra-articular distal humerus fracture management.

Keywords: TRAP, osteotomy, DASH, MEPS

Introduction

Distal humerus fractures accounts for 0.5-7% of all fractures and 30% of elbow fractures [1]. It is more common in young males and older females. Distal intercondylar fractures are the most common fracture pattern [2]. The most common mechanism of injury is low energy falls in elderly and high energy impact in younger population [3]. Adequate exposure of the articular surface is a prerequisite for anatomic reconstruction and stable fixation of these fractures [4-6]. To better visualize the articular surface, olecranon osteotomy [7-9], Bryan-Murray (triceps reflecting) [10] triceps splitting (Campbell) [11], and triceps-reflecting anconeus pedicle (TRAP) [12] approaches have been used. Olecranon osteotomy provides excellent exposure [13, 14]. However, olecranon osteotomy has disadvantages such as delayed union, nonunion, avascular necrosis, heterotrophic ossification, and prominent hardware [7-9, 14, 15].

TRAP approach, as defined by O'Driscoll *et al.*, [12] is an alternative approach in these fracture patterns. This approach is a combination of modified Kocher and Bryan-Morrey, mobilizes the triceps and anconeus muscle of the posterior humerus, and also provides adequate exposure of distal humerus. This approach avoids osteotomy, preserves nerve supplies of anconeus, and has no hardware related problems. On the other hand, some disadvantages with this approach have been reported, such as limited exposure of the articular surface, longer duration of surgery, and weakness of the triceps muscle [13, 16].

The indications and superiority of these two techniques are a question of debate. In the literature, there are limited numbers of studies on this issue [16, 17]. The current study aimed to compare the TRAP approach with olecranon osteotomy regarding their effects on the

functional results of distal humerus fractures treated with open reduction and internal fixation (ORIF).

Materials and Methods

Thirty three patients who were treated with ORIF with the diagnosis of adult distal humerus fracture according to AO/ASIF classification ^[18] between 2014 to 2016 were retrospectively evaluated at GMC (government medical college) Kota. TRAP approach was used in seventeen patients (TRAP group; 10 males, 7 females; mean age 35.9 years, range 17–70 years), and olecranon osteotomy in sixteen patients (Olecranon osteotomy group; 11 males, 5 females; mean age 34.4 years, range 18-62 years). The preference of surgical approach was made by surgeon's discretion.

According to AO/ASIF classification, there was a C1 fracture in 6 patients, C2 fracture in 15 patients, and C3 fracture in 12 patients (Table 1).

Patients with the following were excluded from the study; pathological fractures, open fractures, rheumatoid arthritis treated with corticosteroids for a long period of time, associated ipsilateral forearm fractures, functional loss prior to the fracture, and inadequate follow-up. The mechanism of injury included eleven patients of fall, three cases of traffic accidents, three cases of sports injuries in the TRAP group, and nine patients of fall, five cases of traffic accidents, and two case of sports injury in the olecranon osteotomy group. Six patients had accompanying fractures and two of them had concomitant head and thorax injury.

Table 1: C1 fracture in 6 patients, C2 fracture in 15 patients, and C3 fracture in 12 patients

Parameters	TRAP: N = 17	Olecranon osteotomy (OO): N = 16	p value
Male/Female ratio	10/7	11/5	0.815
Mean age (Range in years)	35.9 (17-70)	34.4 (18-62)	0.629
Mean time from date of injury to surgery	3.2 (2-10)	3.6 (2-11)	
Mean follow up months (Range)	16 (12-20)	16 (12-20)	
AO/ASIF classification C1/C2/C3	5/6/6	3/7/6	0.212

Surgical technique

All patients were prepared in the supine position and tourniquet was applied. A straight posterior longitudinal skin incision was used just lateral to the olecranon tip. Then, ulnar nerve was identified proximally and released distally.

In the TRAP group (Fig-1), the TRAP approach was used for exposure of the elbow which was described by O'Driscoll *et al.* ^[12]. The anconeus muscle was subperiosteally separated from the ulna laterally, preserving the integrity of lateral collateral ligament complex and annular ligament. Along with the anconeus lateral side of the triceps, and then, the medial side were reflected from the olecranon. While the triceps was removed from its insertion, the portion 1 cm distal to olecranon tip was marked with a drill to be used as a guide during closure. The posterior capsule was incised and the dissection was carried out proximally. The fragments were reduced with temporary K-wires. Orthogonal plating was performed in all patients. Then, the triceps was reattached with interrupted number-2 Ethibond suture by using the drillholes through the bone in the olecranon, and the wound

was closed as usual.

In the olecranon osteotomy group (Fig-2), an apex distal, chevron shaped osteotomy was preferred. The osteotomy was performed approximately 2 cm distal to the tip of olecranon. An oscillating saw was used to start osteotomy. An osteotome was used to complete osteotomy by levering the osteotome proximally. These maneuver results in cracking the subchondral bone and creates uneven surface that facilitates reduction. The posterior elbow capsule was then incised and the joint was reached. The fragments were reduced with temporary K-wires. Orthogonal plating was performed in all patients. The proximal fragment of the olecranon was repositioned. Fixation was obtained with a tension band wiring, and the wound was closed as usual.

In twelve patients (7 and 5 patients in the TRAP and olecranon osteotomy groups, respectively) ulnar nerve was in contact with the medial plate in the cubital tunnel, hence subcutaneous anterior transposition of the ulnar nerve was performed in these patients.

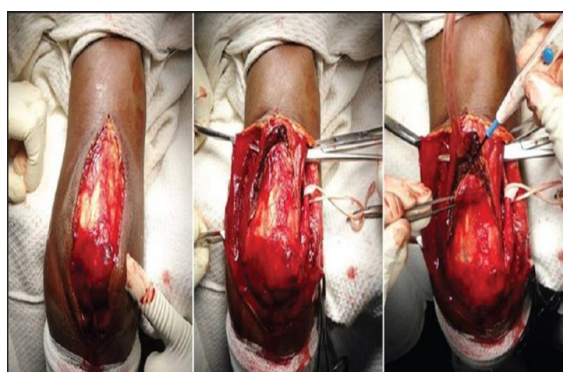


Fig 1: TRAP approach



Fig 2: Olecranon osteotomy

Post-operative care and follow-up

Standard postoperative rehabilitation program was used for ROM exercises applied by a physiotherapist for both groups. In both groups, a removable long arm splint was used for two weeks. Active assisted elbow movements were started on the second postoperative day. In the olecranon osteotomy, active

elbow motion was started at two weeks postoperatively, whereas in the TRAP group, active elbow extension was prohibited until six weeks postoperatively to avoid undue stress on extensor mechanism repair. The patients were followed-up on the first, sixth and twelfth months after surgery.

The patients were radiologically evaluated with anteroposterior and lateral radiographs until fracture union was fully observed. Triceps strength was graded according to the system given by Wolfe *et al.* [20] at the final follow-ups, the functional evaluation of the patients were carried out with goniometric measurement of the range of motion in the elbow joint, Mayo elbow performance score (MEPS) [21], and Disabilities of Arm, Shoulder and Hand (DASH) questionnaire [22]. The MEPS score is based on a 100-point scale which evaluates the pain relief, function, motion and stability of elbow. The MEPS falls in to four grades: ≥ 90 , Excellent; 75–89, Good; 60–74, Fair; < 60 , Poor. Mean duration of follow-up of all patients was 16 months (range 12–20 months).

Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences 18.0 (SPSS Inc., Chicago, IL, USA) software. Statistical significance between variables of both group were analyzed with student's t, chi-square, Fischer's exact, and Mann Whitney U tests. A p value < 0.05 was accepted as significant.

Results

(Fig-3, Fig-4): No significant differences were observed between the groups in terms of gender, age, type of fracture, time to operation, or presence of open or closed fractures ($p < 0.05$). All fractures healed at the end of the follow-up

period. The overall mean arc of elbow motion was 108° (range 70° – 140°) in the TRAP group, whereas that of the olecranon osteotomy group was 102° (range 70° – 130°) (Table-2). No patients had limitation of forearm pronation-supination. Range of motion improved in the first sixth months. At the final control of the patients, mean MEPS was 84.3 (range 55–100) in the TRAP group, whereas that of the olecranon osteotomy group was 82.9 (range 55–100). Although mean MEPS was higher in the TRAP group, no significant difference was noted between the two groups ($p = 0.412$) (Table 2). Mean q-DASH score was 16.6 (range, 0–48) in the TRAP group, whereas that of the olecranon osteotomy group was 18.1 (range 4–57). Although mean q-DASH score was higher in the TRAP group, no significant difference was detected between the two groups (Table 2). No significant difference was found between the groups in terms of fixation technique preferred for distal humerus fracture when considering functional outcomes ($p < 0.05$).

Table 2: Mean q-DASH score was 16.6 (range, 0–48) in the TRAP group

Parameters	TRAP	Olecranon osteotomy (OO)	P value
Mean elbow range of motion (Degree)	108	102	0.112
Mean q-DASH score	16.6 (0-48)	18.1 (4-57)	0.236
Mean MEPS score	84.3 (55-100)	82.9 (55-100)	0.318



Fig 3: Pre-op

Post op after olecranon osteotomy approach



Fig 4: Pre-op

Post op after TRAP approach

Complications

The overall complication rate was 41.17% in the TRAP group and 56.25% in the olecranon osteotomy group. In the TRAP group, ulnar nerve paresthesia developed in one patients, which resolved spontaneously in three months. Triceps muscle weakness was observed in three patients. One patient develop superficial infection which resolved with antibiotic

treatment. Implant failure occurred in one patient at 3 months which was managed by revision orthogonal plating with the same approach. One patient developed deep infection at sixth month. The patient healed with debridement. In the olecranon osteotomy group, two patient develop superficial infection which was managed by IV antibiotics, two patients have complaints of ulnar paresthesia which resolved spontaneously

in 3 months, one patient had delayed union at olecranon osteotomy site which united subsequently at 6 month, while non-union at fracture site occurred in one patient for which osteosynthesis with iliac crest bone grafting was done at 7 month. Three patients came with hardware protrusion and implant irritation problem which was resolved when implant removal was done after union at 18 month.

Table 3: Observation and Olecranon osteotomy

Complications	TRAP	Olecranon osteotomy
Hardware protrusions	0	3
Superficial infection	1	2
Deep infections	1	0
Ulnar neuropathy	1	2
Implant failure	1	0
Extensor weakness	3	0
Delayed union at osteotomy	0	1
Non union	0	1

Discussion

In the current study, no significant differences between TRAP and olecranon osteotomy were found regarding clinical outcomes in distal humerus fractures. When q-DASH scores and MEPS scores were examined, it was observed that the results were better for the TRAP group, but there were no statistically significant difference between the groups. The main purpose in the treatment of intra-articular distal humerus fractures is to achieve perfect anatomical restoration of the articular surfaces, maintain stable fixation and allow early full rehabilitation [23, 24]. Perfect exposure of the fracture is a key factor that allows restoration of articular surfaces. Thus, many approaches were defined, such as olecranon osteotomy, triceps reflecting, triceps splitting, and TRAP approaches [7, 10-12]. Olecranon osteotomy provides the most extensive exposure of the distal humerus. On the other hand, delayed union, nonunion, necessity of implant use to repair osteotomy, and prominent hardware that leads to a second surgery are among the disadvantages [7-9, 14, 15, 23, 24]. Furthermore, nerve supplies of the anconeus muscle might be damaged, as this muscle participates in the dynamic stabilization of the elbow joint, this may cause elbow instability [23].

Wilkinson *et al.* [13] have compared the triceps split, TRAP, and olecranon osteotomy techniques in a cadaveric study. They have found that these techniques demonstrate the joint surfaces at a rate of 35%, 46%, and 57%, respectively. The authors have stated that the best exposure was achieved with the olecranon osteotomy approach (57%), but no statistically significant difference was detected between the TRAP and olecranon osteotomy approaches. We should state that the exposure was better in the olecranon osteotomy group. However, we observed that increasing elbow flexion provides sufficient exposure in the TRAP group, which enables restoration of articular surfaces and stabilization of fracture. Therefore, we believe that relatively less extensive visualization of the distal humerus is not an important drawback to the TRAP approach.

Triceps-elevating exposures were generally claimed with the weakness of extension or rupture of triceps [26]. Ozer *et al.* [16] have used TRAP approach in eleven patients with AO type C fractures. They have performed an isokinetic strength test of involved and uninvolved elbow. Peak torque deficits of the flexor and extensors on the operated and non-operated side were below 20%. They have found no significant impairment of elbow function. Pankaj *et al.* [15] have used TRAP approach in AO type C distal humerus fractures (n=40). They have

reported that thirty-five patients (87.5%) had good triceps strength, four patients (10%) had fair strength, and one patient (2.5%) had poor strength with an extension lag of 10. In the current study, triceps rupture was not observed in any of the patients in which TRAP approach was performed. We found a decrease in the strength of the triceps in three patients in the TRAP. In a detailed examination of these patients, it was also observed that there was also weakness of the flexor muscles in two patients. We suggest that the muscle weakness may be related to the initial injury.

According to O'Driscoll *et al.*, [12] the ideal approach should provide adequate exposure, could be extended when required, should be as soft tissue dissection without osteotomy, the dissection should be in the plane between the nerve, all alternative surgical procedures should be applied with the same exposure, should allow early rehabilitation, and the possible revision should be performed with the same incision. The TRAP approach provides all these requirements [12, 16, 17]. They have reported that TRAP approach provides sufficient exposure for open reduction and internal fixation, and also allows early rehabilitation [12, 25]. Furthermore, after TRAP exposure, there is a chance of total elbow prosthesis in the same session in cases in which the joint surface could not be restored [12]. Restoration of elbow motion is one of the most important parameters in the treatment of intra-articular distal humerus fractures [4-7].

Athwal *et al.* [24] compared the TRAP (n=12) and olecranon osteotomy (n=17) approach in the treatment of type C distal humeral fractures. They found no significant difference between both groups in terms of flexion-extension arc, elbow flexion, elbow extension, pronation, supination, MEPS or DASH score. The authors stated that although they found no statistical difference between both groups, their subgroup analysis must be interpreted with caution because the study was not powered to detect such difference. In the study by Ozer *et al.*, [16] range of motion in Type C1 and C2 (n=9, 82%) had an average of 116° (range 95–140), and Type C3 (n=2, 18%) fractures had an average of 85°. In the study by Pankaj *et al.* [16] the average of range of motion was 118±7 degrees (range 80–140). In our study, the mean arc of motion was better in the TRAP group (108° [range 70°–140°]) when compared to the olecranon osteotomy group (102° [range 70°–115°]). The rate of type C3 fracture in our study was higher (35.3%, and 37.5% in the TRAP and olecranon osteotomy groups, respectively) than the study by Pankaj *et al.* (20%) and Ozer *et al.* [16] (18%), which may explain relatively lower mean arc of motion in our study. In the TRAP group, we used intact olecranon as a template for anatomic reconstruction of the joint. Therefore, we suggest that the use of olecranon joint surface as a template may provide better humero-trochlear joint congruency which may explain the high mean arc of motion in the TRAP group. In addition, the MEPS and q-DASH scores of our study are in line with the literature [16, 17, 25].

Olecranon osteotomy has been associated with a number complications, including delayed union [14] and 0% to 10% risk of nonunion [8, 27]. It was suggested that union problems observed in olecranon osteotomies are mostly related to the transverse osteotomy technique (30%) [28]. Chevron shaped osteotomy reduced these complication [8, 14, 29]. Chevron osteotomy increases contact surface that may promote healing, facilitate reduction and have inherent translational and rotational stability due to interlocking of the proximal and distal fragments [8]. A study by Sanchez-Sotelo *et al.* [30] have reported excellent and good results (79%) using chevron type

osteotomy in the treatment of complex distal humeral fractures.

In the current study, an apex distal, chevron-shaped osteotomy was preferred in the olecranon osteotomy group. Non Union was observed in one patient which was managed by revision surgery using same approach. Delayed union at osteotomy site was observed in one patients, healing was obtained without surgical intervention. The need for a second operation to remove the implants used to repair olecranon osteotomy has been considered as an important shortcoming to the olecranon osteotomy. The risk of requiring subsequent hardware removal has been reported as 13% to 30% [3-8]. Tak *et al.* [30] have used olecranon osteotomy in ninety-four patients and stated that all the unsatisfactory results (average and poor) were seen in those patients who developed complications related to the olecranon osteotomy. In the current study, three patients had implant removal related to the symptom of implants used for olecranon osteotomy repair. In contrast, no patient had a second surgery in the TRAP group. Therefore, when considering a second surgery for implant removal, we suggested that the TRAP approach has a distinct advantage over the olecranon osteotomy approach.

The study has several limitations. Firstly, it is retrospective and comprises a relatively small number of patients. Secondly, orthogonal plating was used for fixation of distal humerus fractures in both groups. Thirdly, we could not make a comparison between sub-groups of the distal humerus fractures e.g. comminuted or osteoporotic fractures. Finally, we could not use isokinetic tests to evaluate the muscle strength. Future studies consisting of specific age groups, homogeneous sub-group types, with similar degree of osteoporotic bone can reveal more accurate results on indications and effectiveness of the TRAP and olecranon osteotomy approaches. Although olecranon osteotomy provides the best exposure, the effect of olecranon osteotomy on the development of osteoarthritis is not well-known. It should be evaluated in long term studies. We consider that the benefit of improved articular exposure must thus be weighed against this relatively high complication rates.

Conclusion

Intrarticular distal humerus fractures requires surgical fixation for best functional outcome. Olecranon osteotomy and TRAP both approaches provides results with satisfactorily clinical results. In this comparative study, no approach is found superior to one another for the clinical and functional outcome.

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